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Inspection
Service

National Boll Weevil Cooperative Control Program

Implementation of the Program in Alabama

1991 Supplement to the Draft Environmental Impact Statement of 1989 (APHIS DEIS 89 - 001)

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Summary

This document is a supplement to the National Boll Weevil Cooperative Control Program Draft Environmental Impact Statement of 1989 (Draft EIS). It contains a site-specific assessment of the potential impacts of implementing the National Boll Weevil Cooperative Control Program in central and northern Alabama. The existing control program, the Southeast Boll Weevil Eradication Program, has been operating in the 21 counties of southern Alabama since 1987.

Chapter 1 of this supplement describes the purpose of and need for implementing the proposed increment of the National Boll Weevil Cooperative Control Program in central and northern Alabama.

Alabama is the eighth largest producer of cotton in the United States. Moreover, cotton is the state's second most valuable crop (after peanuts), with cash receipts totaling $120 million in 1988 (15% of total crop receipts). The boll weevil is the single largest source of cotton damage in Alabama. Between 1981 and 1984, cotton growers' annual control costs averaged $54.48 per harvested acre for boll weevil and *Heliothis* spp. control and $65.32 per harvested acre for controlling all cotton insects and mites. The purpose of the National Boll Weevil Cooperative Control Program in Alabama is to eliminate the boll weevil as an economic pest in the state and reduce the total amount of insecticides needed to control remaining cotton pests in the long term.

Public funds are used to support the program. This is appropriate because the program is expected to result in improvement in environmental quality. The program refines and incorporates new technologies for pest control that can be used in other regions and that can significantly reduce pesticide use. In fact, in areas of the Cotton Belt where eradication has occurred, total cotton pesticide use has decreased 50 to 90%, compared to pre-eradication usage.

Chapter 2 describes the preferred alternative—eradication with full federal involvement; the no action alternative; and current grower practices in southern, central, and northern Alabama. It also discusses the feasibility of an integrated pest management program as it would specifically apply to Alabama. In addition, the chapter describes the standard operating procedures that program personnel would follow during pesticide applications.

The Southeast Boll Weevil Eradication Program (SEBWEP) has been active in 21 counties in southern Alabama since 1987. The proposed program implementation in central and northern Alabama would be under the National Boll Weevil Cooperative Control Program. The organization for the proposed program is expected to be the same as that for the current program, and the proposed program would take an estimated 3½ years to complete. The average number of insecticide treatments applied to infested acreage each season generally ranges from 4 to 11 during the program. Individual fields with exceptionally high numbers of weevils may receive up to 25 treatments. Post-harvest stalk destruction is already widely practiced by growers in the proposed area and will be a component of the program, with credit given for

destruction by certain calendar dates (this may vary each year). Except for boll weevil treatments, other grower practices now in use will likely continue.

The possibility of a true integrated pest management (IPM) strategy in the program area in Alabama was evaluated and determined infeasible. (IPM uses several different techniques, such as cultural practices, pesticides, field surveys, and beneficial insects to manage cotton pests.) Unless broad-spectrum insecticides are heavily used, the relatively warm winters, abundance of overwintering sites, and lack of effective biological controls allow the boll weevil to remain a potential economic pest for the entire season. However, an integrated control strategy can be used with some success. One insecticide treatment can be used at the early pinhead-square stage of cotton development, timed to kill emerging overwintered boll weevils before they lay eggs; then four to five midseason treatments can be used. Limiting early season treatments to a single application would give the beneficial insects time to rebuild their populations to levels that can help suppress other insect pests; then four to five treatments beginning in early July should provide adequate control of boll weevils for the rest of the season.

Chapter 3 of this site-specific assessment contains a detailed description of the environmental resource elements in Alabama that may be affected by the proposed implementation of the National Boll Weevil Cooperative Control Program in the central and northern parts of the state. These elements include geology and topography, climate, soils, vegetation, nontarget terrestrial wildlife and aquatic species, human populations, socioeconomics, cultural and visual resources, water and air quality, and noise.

Chapter 4 contains an analysis of the potential impacts of expanding the existing SEBWEP into central and northern Alabama as they relate to the respective environmental resource elements described in chapter 3.

No impacts from the proposed program are expected on geology and topography or climate. No significant impacts are expected on cultural and visual resources, and no significant changes to noise level are expected. New information from the literature suggests that malathion has caused some damage to a variety of vegetation and that some formulations of methyl parathion may be somewhat toxic to cotton, in particular.

If there are any impacts on water quality, they are expected to be short-term because the pesticides degrade rapidly and are diluted as they reach larger rivers and streams. The surface waters that could have the highest concentrations of insecticides are generally farm ponds and smaller streams. Maximum impacts to aquatic species could occur closest to the point of discharge, and in most cases, the dilution that occurs immediately downstream of the point of discharge would reduce any insecticide concentrations to safe levels.

Wildlife and aquatic species may be affected if they are exposed to the program pesticides, or they may be momentarily disturbed by the application equipment during implementation of SEBWEP into central and northern Alabama. Only individual animals might be affected. No major population of wildlife or aquatic species is likely to be seriously

affected, and no other aspects of the program are likely to affect them.

Two groups of people may be affected by the proposed boll weevil control program in Alabama—workers and certain members of the public. The workers would include program personnel and contract applicators involved in applying one of the three program insecticides or engaged in other boll weevil control activities. Members of the public may be affected only if they are near the edge of a cotton field while it is being treated or if they consume food or water with insecticide residues. The health and safety of others should not be affected by the program.

Workers could be injured during operation of the aircraft, hiboys, or mist blowers used in application of the program insecticides. There is some risk of fatalities from those injuries, particularly in the case of an aircraft accident. Routine safety precautions that are among the standard operating procedures (chapter 2, table 2-7) for aircraft and farm equipment use should minimize the possibility of serious injuries or fatalities. The public is not at significant risk of injury from these types of accidents.

There is some risk that workers and the public may become ill from being exposed to the program insecticides. In particular, malathion and methyl parathion are among the organophosphate pesticides known to interfere with the functioning of the human nervous system by binding to the enzymes involved in transmitting nerve signals. Repeated smaller doses are effectively equivalent to a single large dose because this binding process is irreversible until the body has had enough time to manufacture additional enzymes. Diflubenzuron does not produce this effect. Sufficient enzyme inhibition can lead to symptoms of poisoning, such as headaches, nausea, and dizziness. Fatalities may result from severe exposures if immediate treatment is not available, but the possibility of this level of exposure would be limited to the workers who routinely handle large quantities of the insecticide concentrates. No member of the public is likely to receive such a high dose. Laboratory animal studies have produced some evidence that significant doses of the control program insecticides might also produce longer term health effects, such as reproductive effects or cancer, in exposed individuals (see the section on human health and safety in chapter 4).

Appendix A contains a discussion of the insecticide fate modeling, human health risk assessment, and terrestrial wildlife and aquatic species risk assessment (see the section on nontarget terrestrial wildlife and aquatic species in chapter 4).

Appendix B describes the endangered, threatened, and proposed plant, wildlife, and aquatic species that occur in Alabama's cotton-producing counties, their habitats, and the possible effects that expansion of SEBWEP might have on them. A risk assessment was conducted to determine which species might be affected and what those effects might be. There are 46 endangered, threatened, or proposed species in cotton-producing counties in Alabama. Of those 46, it was determined that 34 may be adversely affected either by direct toxic or indirect toxic effects of the program insecticides, or that they may otherwise be disturbed by boll weevil control measures or insecticide application methods (for example, the noise of spray planes).

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Chapter 1

Purpose and Need

Introduction

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), in cooperation with the Alabama Department of Agriculture and Industries and the Southeast Boll Weevil Eradication Foundation, proposes to implement the National Boll Weevil Cooperative Control Program in central and northern Alabama. Alabama is part of the proposed National Boll Weevil Cooperative Control Program described and evaluated in volume 1 of the Draft EIS.

This supplement presents information not included in the Draft EIS about the existing boll weevil eradication program in southern Alabama and evaluates the proposed implementation of the program in the rest of the state. Program details and impacts that are the same in Alabama as in the rest of the Cotton Belt are not repeated in this supplement; where appropriate, the text refers the reader to parts of volume 1 of the Draft EIS.

This chapter discusses the purpose of and need for implementing the National Boll Weevil Cooperative Control Program in Alabama. The status of previously eradicated areas in the national program is also presented. Chapter 2 describes the National Boll Weevil Cooperative Control Program's preferred alternative, eradication with full federal involvement, as it would be specifically implemented in central and northern Alabama. Chapter 3 describes Alabama's environmental resources, and chapter 4 evaluates the potential impacts of eradication on these resources. Chapter 5 explains the conclusions reached about the potential environmental impacts of implementing the control program in central and northern Alabama. Details about the fate modeling of the program insecticides and the human health and wildlife risk assessments are presented in appendix A. Appendix B describes the federally listed endangered, threatened, and proposed plant and wildlife species in Alabama, analyzes the potential effects of the control program on these species, and describes measures to protect those species.

Purpose

The first chapter of volume 1 of the Draft EIS describes the purpose of the National Boll Weevil Cooperative Control Program. The objective of implementing the program in central and northern Alabama is to eradicate the boll weevil as an economic pest in Alabama. Achieving this objective will help maintain the previously eradicated areas in the Southeast (Florida, Georgia, South Carolina, North Carolina, and Virginia). The program's success in achieving previous increments has demonstrated the feasibility of the eradication alternative. APHIS and program cooperators recognize that there are cotton producers and members of the scientific community who question the feasibility of eradication. The ultimate goal of eradication is to eliminate the boll weevil, thereby reducing the total amount of pesticides used in cotton production.

Need for Eradication

Alabama is the eighth largest producer of cotton in the United States. Moreover, cotton is Alabama's second most valuable crop (after peanuts), with cash receipts totaling $120 million in 1988. Cotton revenues represented 15% of total crop receipts in 1988, and 5% of all farm commodity receipts (Alabama Department of Agriculture and Industries (ADAI), 1990).

The boll weevil is the single largest source of cotton damage in Alabama. Continuing crop losses from the boll weevil and the resultant high annual control costs are principal contributors to the high cost of producing cotton in Alabama. Between 1981 and 1984, the boll weevil was responsible for 5% of the total loss of cotton yield caused by insects and mites; four other major cotton pests (*Heliothis* spp., plant bugs, thrips, and spider mites) were responsible for a total yield loss of 6%. Cotton growers' annual control costs averaged $54.48 per harvested acre for boll weevil and *Heliothis* spp. control and $65.32 per harvested acre for controlling all cotton insects and mites. The value of the cotton destroyed by the boll weevil and the cost of boll weevil control averaged $21.9 million annually, 67% of the total value of the $32.8 million cost of cotton yield loss and control of all cotton pests (Suguiyama and Osteen, 1988).

The boll weevil (*Anthonomus grandis*) immigrated into the United States from Mexico and into Alabama in the early 1900s. Because the boll weevil does not have many natural enemies, chemical insecticides are heavily relied upon for controlling this pest. Boll weevils overwinter in well-drained, protected places in and around cotton fields and come out of hibernation to enter cotton fields in May and June. A surge of emerging weevils often occurs after a spring rain. A complete life cycle requires approximately 3 weeks, allowing five generations to occur annually in Alabama.

Authority exists under the Organic Act of 1944, as amended (7 U.S.C. 147a), for the Secretary of Agriculture to cooperate with the states or political subdivisions thereof; farmers' associations and similar organizations; and individuals to detect, eradicate, suppress, control, prevent, or retard the spread of plant pests. The Alabama Boll Weevil Eradication Act of 1984 (84-786) allows the Boll Weevil Eradication Foundation of Alabama to participate in the Southeastern Boll Weevil Eradication Program (SEBWEP).

Status of Previously Eradicated Areas

Cotton producers in the eradicated areas of the Cotton Belt have been able to reduce their total pesticide use by 50 to 90%. The corresponding reduction in production costs has allowed these growers to produce cotton more profitably and will ultimately make their cotton more competitive in U.S. and world markets. Cotton acreage has increased in these eradicated areas, which has had direct and indirect benefits in many rural communities.

In areas where the boll weevil has been eradicated, beneficial insects can and have been carefully managed to control secondary pests. Because the program has eliminated the traditional need for early-season boll weevil control, beneficial insects have been much more effective in controlling secondary pests. The program has also demonstrated effective ways of using biological controls on secondary pests following boll weevil eradication. Thus, the amount

of chemical pesticides applied to control secondary pests has been dramatically reduced.

Virginia

In the late 1970s only a few hundred acres of cotton were grown in Virginia; in 1991 about 17,000 acres were planted, and at least one new cotton gin has been constructed. It has been more than 5 years since the last boll weevil was trapped in Virginia, and there is no indication that another pest has filled the boll weevil's niche (USDA, 1990). Total insecticide applications for growers in this area have been reduced from 10 to 12 per year to an average of 2 applications per year (Planer, 1988).

North and South Carolina

In 1977 when the program began in North Carolina, approximately 40,000 acres of cotton were grown in the state. In 1990 more than 200,000 acres were planted in North Carolina. Projected acreage for 1991 is more than 450,000. Since 1980 there have been more than 25 major cotton gins constructed or renovated in North Carolina. This expanded ginning capacity provides employment for 100 full time and 200 seasonal employees (personal communication with W. Dickerson, 1991). It is likely that there has been a comparable effect on the farm implements and supply industries. The program expanded into South Carolina in 1983 when the state produced about 100,000 acres of cotton. By 1990 the cotton acreage in South Carolina increased to about 150,000 acres, with more than 200,000 acres expected in 1991. Growers in these two states now apply an average of only three to six insecticide applications (Planer, 1988), predominantly for *Heliothis* spp. (USDA, 1990). In the North Carolina program area, insecticide applications for controlling all remaining cotton pests decreased 88% compared to pre-program applications (Lloyd, 1986; as cited in Matthews, 1989). These environmental and economic benefits will continue indefinitely.

California, Arizona, and Mexico

The Southwest Eradication Program was begun in 1985 and, like the Southeast Eradication Program, has been successful. The Southwest program differs from the Southeast program in several ways. It was found that boll weevils in the Southwest program area emerge from localized areas close to suitable overwintering sites, primarily near rivers, irrigation canals, and residential areas near cotton fields. In addition, compared to the Southeast, weevil populations were relatively low in the spring. Therefore, areawide diapause treatments were not used the first fall of the program as they had been in the southeastern states. In subsequent years selective diapause treatments were used to complete eradication (Planer, 1989). The original Southwest program area covered 227,000 acres in southern California, western Arizona, and northwest Mexico. In 1989 only 823 weevils were trapped in the entire area, and in 1990, none had been caught as of July (Foster, 1990). The expanded program began in 1988 and covered 480,000 acres in central Arizona and 5,000 acres in Mexico. During the first year, more than 4.2 million weevils were trapped and 900,000 cumulative acres were treated. In 1990 fewer than 2,500 had been captured as of July and only 12,098 cumulative acres had been treated (Foster, 1990). Eliminating the boll weevil in Southwest cotton production areas will enable growers to more effectively manage the remaining cotton pests, such as pink bollworms and whiteflies.

The success of boll weevil eradication in these widely varying environments located at opposite ends of the Cotton Belt suggests that the eradication program in Alabama should be successful.

Chapter 2

Alternatives

Overview

This chapter describes how the National Boll Weevil Cooperative Control Program's preferred alternative, eradication with full federal involvement, would be implemented in central and northern Alabama (fig. 2-1). Current grower practices (those not funded by the Animal and Plant Health Inspection Service (APHIS)) that would constitute the no action alternative are explained, as is the feasibility of an integrated pest management (IPM) alternative in Alabama. The chapter also briefly reiterates the control methods now used in the 21 southern counties and discusses which of the control methods described in volume 1 of the Draft EIS would be available for use when the program begins in central and northern Alabama. Standard operating procedures and a summary of potential impacts of implementing the preferred alternative in Alabama are also included.

The other alternatives—eradication with limited federal involvement, suppression with full federal involvement, suppression with limited federal involvement, nonchemical control only, and direct subsidy to growers—will not be evaluated here. Volume 1 of the Draft EIS contains a full discussion of those alternatives.

Current Alabama Cotton Grower Practices

Northern Alabama

Planting and Harvesting Practices

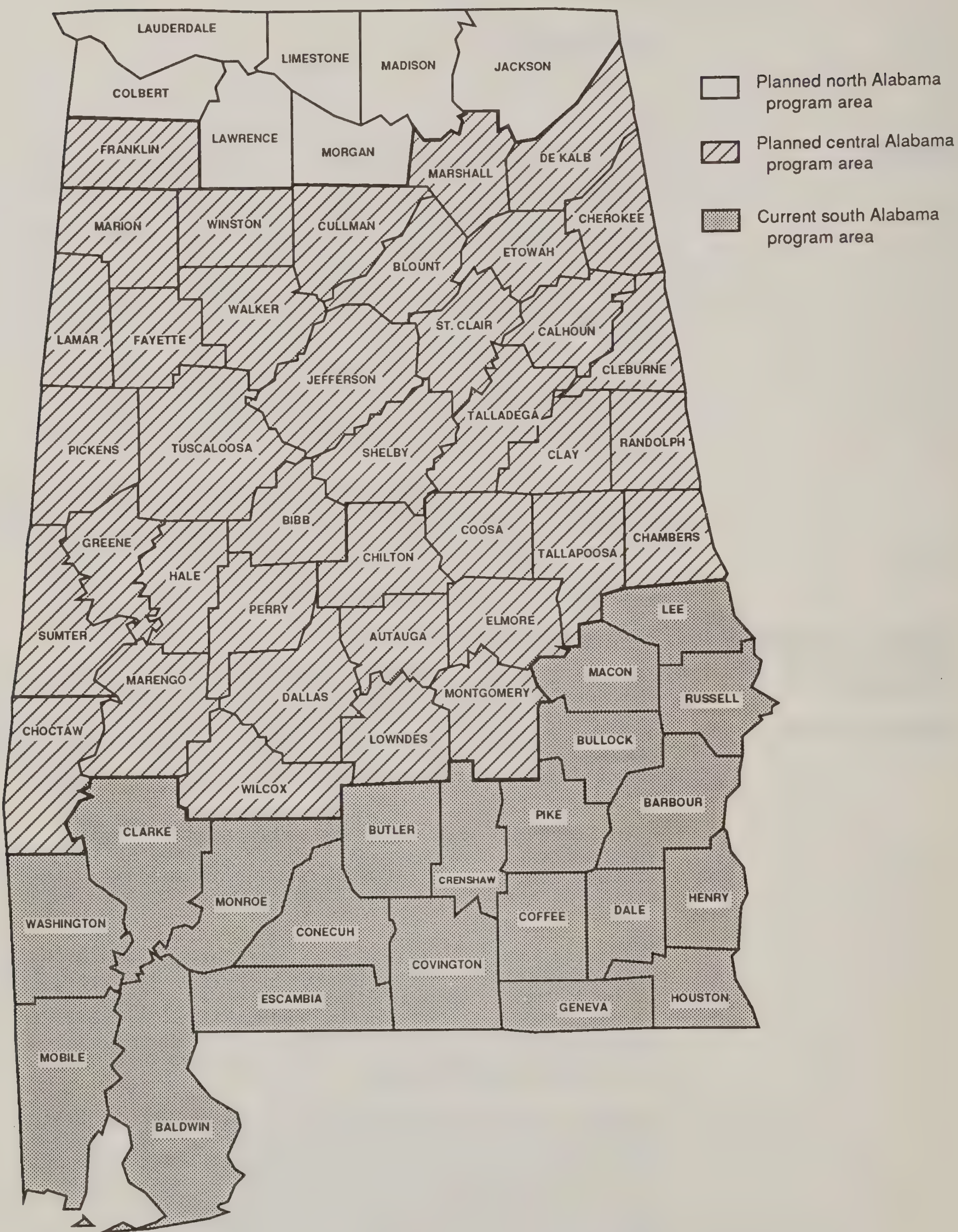
Between 1985 and 1988 an average of 179,103 acres (5.65% of the total land area in the northern counties) of cotton were planted in northern Alabama (Alabama Agricultural Statistics Service, 1988). The largest number of acres were planted in Limestone County, with an average of 51,800; the fewest acres were planted in Jackson County, with an average of 643.

Planting dates vary with the severity of a region's winter. Most cotton in northern Alabama is planted during April. If winters are especially mild, some planting may occur in late March; if they are colder than normal, planting may continue into early May.

The cotton varieties planted in northern Alabama consist only of regular-season cotton varieties, with DPL® 50 being the most widely used. Other common varieties include Stoneville® 453, DES® 119, KC® 380, and to a lesser extent, Stoneville® 825. Short-season cotton varieties are not used in northern Alabama, according to a personal communication with Barry Freeman (1990).

Growers chemically manipulate cotton growth to facilitate the harvest and reduce insect problems. For example, when cotton becomes too tall or its vegetative growth is excessive, it is difficult to harvest efficiently, the efficiency of insecticide applications may be reduced, and the cotton may be more prone to boll rot (Alabama Cooperative Extension Service, 1990). In addition, delayed fruiting and excessive vegetative growth (which provides more shade and moisture) encourage higher, longer lasting insect infestations during the growing season. To help alleviate these situations,

Fig. 2-1. Current and planned program areas



PIX® (mepiquat-chloride), a cotton growth regulator, is used by 80% of the growers on approximately 80% of their fields. PIX® slows plant growth, resulting in a more compact plant with clustered bolls, and causes cotton to mature earlier (Alabama Cooperative Extension Service, 1990). (Cotton treated with PIX® matures 4 to 7 days earlier than untreated cotton, according to a personal communication with Barry Freeman, 1990). In addition, because PIX® reduces vegetative growth and encourages early fruiting, it helps combat late-season insect populations (Alabama Cooperative Extension Service, undated).

Chemical defoliants are also used to facilitate the harvest. The most commonly used defoliant in northern Alabama is Dropp®, which causes squares as well as leaves to fall and discourages cotton regrowth. When the squares fall from the plant, they begin to rot, and most of the young boll weevils inside will die.

After the harvest, growers generally destroy the cotton stalks. There is no mandatory date for cotton-stalk destruction in northern Alabama; however, because of the heavy clay soil in that part of the state, most growers shred the stalks as soon after the harvest as possible (sometimes shredders are in the same field behind the cotton pickers) and plow soon after to break up the soil. If plowing were left until spring, the clay soil would be difficult to break up because of the compaction that occurs during winter freezes. Erosion is usually not a problem unless winter rains are heavy, according to a personal communication with Barry Freeman (1990).

Cotton Pest Control

Each field is scouted once or twice a week for pests. Either the grower, an Extension Service-trained scout, or a professional consultant does the scouting (Alabama Cooperative Extension Service, undated). The important insect pests on cotton in northern Alabama are thrips, aphids, budworms and bollworms (*Heliothis* spp.), tarnished plant bugs, spider mites, and boll weevils. These pests are controlled as follows (table 2-1 lists the active ingredient, application rates, number of applications, and percentage of acreage receiving treatments during the season):

The following information was obtained from a personal communication with Dr. Ron Smith, Auburn University.

- Thrips—Ninety percent of the fields in northern Alabama are treated with an in-furrow application of the systemic insecticides Temik®, Thymet®, or Disyston® at planting. Temik® is used approximately 75% of the time. Granular formulations of these insecticides are dropped in the planting furrow with the cottonseed. Approximately 50% of the acreage receives a foliar application of either Orthene®, Bidrin®, or Cygon® on seedlings for further control when the cotton is in the two- to four-true-leaf stage. These insecticides are applied with ground equipment during cultivation. A single nozzle directed a few inches above the plants sprays a 10-inch swath.

Table 2-1. Pesticides likely to be used in current grower practices in NORTHERN ALABAMA[a]

Trade name	Active ingredient	Rate of application (lb a.i./acre)	Number of applications	Percent of fields treated	Time of year	Pests targeted
Temik®	Aldicarb	3.5–4 lb/acre	1	90	Planting	Thrips
Orthene® Bidrin® Cygon®	Acephate Dicrotophos Dimethoate	0.15 lb/acre 0.15 lb/acre 0.15 lb/acre	1 treatment from among these pesticides	50	April–May	Thrips
Methyl parathion	Methyl parathion	0.33 lb/acre	1	50	June	Boll weevils[b]
Vydate®	Oxamyl	0.225–0.9 lb/acre	1	10	June	Boll weevils[b]
Larvin® Curacron® Various pyrethroids	Thiodicarb Profenophos	0.5 lb/acre 0.5 lb/acre 0.25–0.5 lb/acre	1 treatment from among these pesticides	33	June	*Heliothis* spp.
Orthene® Bidrin® Pyrethroids Methyl parathion	Acephate Dichrotophos Methyl parathion	0.5–1 lb/acre 0.1–0.5 lb/acre label rate 0.25–2 lb/acre	1 treatment from among these pesticides	60	June	Tarnished plant bug
Bidrin® MetaSystox–R®	Dicrotophos Oxydemeton	0.1–0.5 lb/acre 0.25–0.5 lb/acre	1.5 treatments of one or the other pesticides	100	June	Aphids
Karate® Baythroid® Asana® Ammo®	Lambda cyhalothrin Cyfluthrin Esfenvalerate Cypermethrin	0.25 lb/acre 0.028 lb/acre 0.03 lb/acre 0.05 lb/acre	3 treatments from among these pesticides	100	July–August	*Heliothis* spp.

Table 2-1. Pesticides likely to be used in current grower practices in NORTHERN ALABAMA[a] (continued)

Trade name	Active ingredient	Rate of application (lb a.i./acre)	Number of applications	Percent of fields treated	Time of year	Pests targeted
Methyl parathion	Methyl parathion	0.33 lb/acre	3 to 6 treatments from among these pesticides	100	July–August	Boll weevils[b]
Guthion® 2S	Azinphos-methyl	0.25 lb/acre				
Karate®[c]	Lambda cyhalothrin	0.025 lb/acre				
Baythroid®[c]	Cyfluthrin	0.028 lb/acre				
Curacron®	Profenofos	0.5 lb/acre	1 treatment from among these pesticides	25	Any time	Spider mites
Lorsban®	Chlorpyrifos	0.5 lb/acre				
Capture®	Bifenthrin	0.5 lb/acre				

[a]Applications may be ground or aerial, depending on individual circumstance.
[b]If boll weevils are present.
[c]If *Heliothis* spp. is also present.

- Aphids—Aphids are a greater problem in northern Alabama than in other parts of the state. They have also become resistant to most insecticides. Nevertheless, all growers treat their cotton at least once during the season, between July 15 and August 1, when cotton is reaching its peak fruiting period, and about half of them treat twice—usually with Bidrin® or Metasystox-R®. The insecticide usually is applied with ground equipment.

- *Heliothis* spp.—Early-season (June 15 to June 20) control of budworms and bollworms is needed on approximately one-third of the cotton acreage. Larvin®; Curacron®; or a pyrethroid such as Karate®, Baythroid®, Asana®, Cymbush®, Ammo®, or Scout® is normally used. In-season (July 20 to August 20) pesticide applications include treating for budworms and bollworms with Karate®, Baythroid®, Asana®, or Ammo®. Approximately 80% of the treatments are done using ground equipment, and approximately 20% of the treatments are done with aircraft.

- Tarnished plant bug—An estimated 60% of the cotton in northern Alabama is usually treated for this early-season (June 15 to July 1) pest with Orthene®, Bidrin®, one of the pyrethroids, or methyl parathion. Treatments are done with ground equipment about 80% of the time and by aircraft about 20% of the time.

- Spider mites—Spider mites can be a problem any time throughout the growing season, although they more typically become a problem in mid- to late season. Approximately 25% of the cotton acreage is usually treated with Curacron®, Lorsban®, or Capture® to control spider mites. Approximately 20% of the applications are aerial, and approximately 80% are done with ground equipment.

- Boll weevils—Boll weevils are a cyclic problem in northern Alabama. Higher populations usually occur after warm winters. In years when they are an economic problem, approximately 50% of the acreage will receive a pinhead-square treatment of methyl parathion, and 10% will be treated with Vydate®. Ground equipment is used for these applications in early to mid-June (June 5 to June 20). Multiple treatments with organophosphates early in the season are usually avoided because they eliminate beneficial insects; also, the tarnished plant bug and aphids are resistant to them, thus increasing the probability of uncontrollable infestations of these two species. The selection of chemicals for treating boll weevils in July and August depends on the presence or absence of *Heliothis* spp. If growers are having a problem with boll weevils but not *Heliothis* spp., they may use up to six in-season applications of methyl parathion or Guthion® on all the fields. These are applied by ground equipment (80%) and by aircraft (20%). If *Heliothis* spp. are also present, growers would probably use Karate® or Baythroid®. During years when boll weevils are a problem, growers mix methyl parathion with their defoliant, which is applied aerially.

Central Alabama

Planting and Harvesting Practices

The average number of cotton acres planted in central Alabama from 1985 to 1988 was 101,495 (0.57% of the total land area), ranging from a high in Dallas County of 15,790 to a low in Winston, Clay, Coosa, and Randolph Counties, where no cotton was planted (Alabama Agricultural Statistics Service, 1988).

In central Alabama, most cotton is planted between April 15 and May 15 of each year. Planting may begin a little earlier or a little later, depending on the temperature and the timing of spring rains.

The most common cotton varieties planted are DPL® 90, DPL® 50, Coker® 315, DES® 119, Stoneville® 456, and DPL® 41. Short-season varieties are not used often; they do not produce well because of central Alabama's erratic rainfall.

Chemical defoliants are used in central Alabama to facilitate harvest. Defoliants reduce the risk of boll rot and can facilitate the picking schedule. Dropp®, a commonly used defoliant, also discourages regrowth.

Though not mandatory, stalks are shredded as soon as possible after harvest and left in place through the winter to help prevent erosion.

Cotton Pest Control

In a normal year in central Alabama, growers use 6 to 12 insecticide applications per cotton field, with an average of 8. The need for an application is determined by scouting each field. The important cotton pests in central Alabama are thrips, aphids, spider mites, whiteflies, *Heliothis* spp., and boll weevils; *Heliothis* spp., aphids, and boll weevils cause the most damage. These pests are controlled as follows (table 2-2 lists the active ingredient, application rates, number of applications, and percentage of the acreage receiving treatments during the season), according to a personal communication with Dr. Ron Smith (1990):

- Thrips—Temik® is applied with the cottonseed in furrows at planting. A granular formulation of this insecticide is dropped in the planting furrow with the cottonseed. Bidrin® and Di-Syston® are also used shortly after the seedlings emerge.

- Aphids, spider mites, and whiteflies—These pests are treated in the early season with Bidrin® and Metasystox-R® and at least one treatment of one of the following: Curacron®, Lorsban®, Monitor®, or Orthene®.

- *Heliothis* spp.—*Heliothis* spp. are treated approximately six times with any one of the following pyrethroids: Karate®, Baythroid®, Asana®, Cymbush®, Ammo®, or Scout®.

- Boll weevils—Methyl parathion is applied in June (early season) to control overwintered boll weevils; approximately one-half the cotton acreage is treated four times in July and August (in season) with Guthion® 2S or methyl parathion.

Table 2-2. Pesticides likely to be used in current grower practices in CENTRAL ALABAMA[a]

Trade name	Active ingredient	Rate of application (lb a.i./acre)	Number of applications	Percent of fields treated	Time of year	Pests targeted
Temik®	Aldicarb	3.5 lb/acre	1.5	40	April-May planting	Thrips
Bidrin®	Dicrotophos	0.2 lb/acre	1	30	May	Thrips
Di-Syston®	Disulfoton	7 lb/acre	1	20	May	Thrips
Methyl parathion	Methyl parathion	0.25 lb/acre	1.5	40	June	Boll weevil
Karate®	Lambda cyhalothrin	0.025 lb/acre	6	30	June	*Heliothis* spp.
Baythroid®	Cyfluthrin	0.028 lb/acre	6	30	June	*Heliothis* spp.
Asana®	Esfenvalerate	0.03 lb/acre	6	20	June	*Heliothis* spp.
Cymbush®/Ammo®	Cypermethrin	0.05 lb/acre	6	15	June	*Heliothis* spp.
Scout®	Tralomethrin	0.018 lb/acre	6	5	June	*Heliothis* spp.
Bidrin®	Dicrotophos	0.2 lb/acre	1.5	40	June	Spider mites, whiteflies, aphids, and plant bugs
MetaSystox-R®	Oxydemeton	0.125 lb/acre	1.5	40	June	
Curacron®	Profenofos	0.5 lb/acre	At least 1 treatment from among these pesticides	50	June	Spider mites, whiteflies, aphids, and plant bugs
Lorsban®	Chlorpyrifos	0.5 lb/acre				
Swat®	Phosphamidon	0.25 lb/acre				
Monitor®	Methamidophos	0.25 lb/acre				
Orthene®	Acephate	0.5 lb/acre				
Larvin®	Thiodicarb	0.5 lb/acre	1	30	June	Beet armyworm
Guthion® 2S	Azinphos-methyl	0.25 lb/acre	4	50	July–August	Boll weevil
Methyl parathion	Methyl parathion	0.25 lb/acre	4	50	July–August	Boll weevil

[a]Applications may be ground or aerial, depending on individual circumstance.

- Beet armyworm—A single, aerial application of Larvin® is usually made in mid-season (late July) if beet armyworms are a problem.

All modes of application are identical to those used in northern Alabama except where specified.

Southern Alabama

Planting and Harvesting Practices

From 1985 to 1988 an average of 61,268 acres of cotton were planted (0.55% of the total land area) in southern Alabama. The largest number of acres were planted in Monroe County, with an average of 8,750; Clarke County had the fewest acres, with an average of 158 (Alabama Agricultural Statistics Service, 1988).

Growers in southern Alabama use planting and harvesting practices similar to those in central Alabama, according to a personal communication with Dr. Ron Smith (1990).

Cotton Pest Control

As with planting and harvesting practices, cotton pests and the control methods used in southern Alabama are similar to those in central Alabama, with the exception of the following (see table 2-3 for information on the active ingredient, application rates, number of applications, and percentage of acreage receiving treatments during the season):

- Beet armyworm—The beet armyworm, a migratory insect that starts in the south and progresses north, is a greater economic problem in southern Alabama than in other parts of the state. An estimated six applications of Larvin® at a rate of 0.5 lb a.i./acre are usually made on about 30% of the cotton acreage. Another 20% of the acreage is treated three times with Curacron® at a rate of 1 lb a.i./acre, and Dimilin® is applied on 30% of the acreage two or three times during the season at a rate of 1 to 2 oz a.i./acre.

- Boll weevils—Since the beginning of the Southeast Boll Weevil Eradication Program in 1987, no growers in the 21 southern counties have used boll weevil treatments.

All modes of application are identical to those used in northern and central Alabama except where specified.

The Current Boll Weevil Eradication Program

Organization of the Southeast Boll Weevil Eradication Program

The Southeast Boll Weevil Eradication Program (SEBWEP) is a cooperative federal-state-cotton producer program designed to eradicate the boll weevil as an economic cotton pest within the Southeastern United States. The Southeastern Boll Weevil Eradication Foundation, Inc. (Southeastern Foundation) is a nonprofit corporation. The Southeastern Foundation is made up of the Boll Weevil Eradication Foundations of Alabama, Florida, Georgia, North Carolina, and South Carolina; and the Virginia Department of Agriculture and Consumer Services. The Southeastern Foundation is the grower organization that cooperates with

Table 2-3. Pesticides likely to be used in current grower practices in SOUTHERN ALABAMA[a]

Trade name	Active ingredient	Rate of application (lb a.i./acre)	Number of applications	Percent of fields treated	Time of year	Pests targeted
Temik®	Aldicarb	3.5 lb/acre	1.5	40	April planting	Thrips
Bidrin®	Dicrotophos	0.2 lb/acre	1	30	May	Thrips
Di-Syston®	Disulfoton	7.0 lb/acre	1	20	May	Thrips
Karate®	Lambda cyhalothrin	0.025 lb/acre	6	30	June	*Heliothis* spp.
Baythroid®	Cyfluthrin	0.028 lb/acre	6	30	June	*Heliothis* spp.
Asana®	Esfenvalerate	0.03 lb/acre	6	20	June	*Heliothis* spp.
Cymbush®/Ammo®	Cypermethrin	0.05 lb/acre	6	15	June	*Heliothis* spp.
Scout®	Tralomethrin	0.018 lb/acre	6	5	June	*Heliothis* spp.
Bidrin®	Dicrotophos	0.2 lb/acre	1.5	40	June	Spider mites, whiteflies, aphids, and plant bugs
MetaSystox-R®	Oxydemeton	0.125 lb/acre	1.5	40	June	Spider mites, whiteflies, aphids, and plant bugs
Curacron®	Profenofos	0.5 lb/acre	At least 1 treatment from among these pesticides	50	June	Spider mites, whiteflies, aphids, and plant bugs
Lorsban®	Chlorpyrifos	0.5 lb/acre				
Swat®	Phosphamidon	0.25 lb/acre				
Monitor®	Methamidophos	0.25 lb/acre				
Orthene®	Acephate	0.5 lb/acre				
Larvin®	Thiodicarb	0.5 lb/acre	1	30	June	Beet armyworm
Larvin®	Thiodicarb	0.5 lb/acre	6	30	July–August	Beet armyworm
Curacron®	Profenofos	1.0 lb/acre	3	20	July–August	Beet armyworm
Dimilin®	Diflubenzuron	1-2 oz/acre	3	30	July–August	Beet armyworm

[a]Applications may be ground or aerial, depending on individual circumstance.

USDA—APHIS-Plant Protection and Quarantine (PPQ) in implementing and operating SEBWEP.

The Board of Directors of the Southeastern Foundation consists of three board members (one regulatory and two growers) from each state who are elected by the individual state foundations. The Chairman, Vice Chairman, and Secretary/Treasurer are elected by the Board of Directors for a 1-year term. The Southeastern Foundation hires employees to work with USDA-APHIS employees in conducting the activities of SEBWEP. Field unit supervisors meet the basic standards for USDA GS-5 Plant Protection Technicians. The Southeastern Foundation, in cooperation with USDA-APHIS and in coordination with the cooperative agreement between the Southeastern Foundation and USDA-APHIS (SEBWEP, 1989), provides permanent and temporary field and office personnel to conduct program activities; assists in organizing educational and informational meetings for cotton growers; assists in resolving grower concerns about program activities; and solicits bids and issues contracts, in cooperation with USDA-APHIS for pesticide purchases, aerial pesticide applications, and other materials and services needed for program operation; and provides traps for the program from plastic injection molds and other equipment (SEBWEP, 1989).

Each state foundation collects grower assessments and remits them to the Southeastern Foundation to conduct SEBWEP—excluding $2,000 for the state foundations' annual meeting and other amounts needed to prepare annual audits. The Southeastern Foundation is responsible for accounting for all funds, including the 30% provided by USDA—APHIS-PPQ (SEBWEP, 1989).

The SEBWEP has changed over its duration in response to local concerns. Some of those concerns have alleged fish kills, human illness, spraying occupied fields, pesticide drift, and animal or livestock illness. Table 2-4 summarizes the complaints received by program staff from 1987 to 1990 and their responses. Investigation of these complaints revealed that several of them appeared valid, and APHIS program procedures were modified to minimize the risk of future occurrences. Many of these risks were minimized by improving pilot education, adjusting spray equipment, reducing spray height, notifying potentially affected parties in advance, and eliminating the use of azinphos-methyl in Alabama. A more complete analysis of the complaints may be found in the 1988 Spring-Summer Boll Weevil Suppression Program Environmental Assessment (USDA, 1988).

The Southeast Boll Weevil Eradication Program in Alabama

Program Organization. The southeast program is divided into three areas, which are subdivided into 10 work units ranging in size from approximately 20,000 to 46,000 acres. There are two work units within the 21-county program area in Alabama. One is headquartered in Eufaula, Alabama; the other is in Jay, Florida. Each work unit is staffed by the following APHIS employees: an Officer-in-Charge (OIC), an Assistant-Officer-in-Charge (AOIC), and a Plant Protection and Quarantine (PPQ) Officer; in addition, the Southeastern Foundation provides a secretary, 8 to 10 field unit supervisors responsible for day-to-day operations, and 40 to 50 trappers.

Table 2-4. Summary of types of complaints

A. Problem with pesticide application (originates from the general public and possibly cotton growers)

- **A1.** Fish kill
- **A2.** People sprayed—human illness
- **A3.** Livestock/fowl illness
- **A4.** Sprayed house, cars, etc.
- **A5.** Bee kill
- **A6.** Spraying in wind above 10 mph—excessive drift
- **A7.** Flying too high
- **A8.** Spraying outside target area
- **A9.** Pesticide spill or dump
- **A10.** Aircraft turning too close to house or school

B. Quality and scheduling of pesticide application (originate from cotton growers)

- **B1.** Aircraft observers not adequately monitoring treatment
- **B2.** Program aircraft interfere with private aircraft
- **B3.** Field not treated
- **B4.** Field not treated on time
- **B5.** Inadequate field coverage
- **B6.** Grower not adequately informed of treatment schedule
- **B7.** Inadequate control—boll weevil damage detected

C. Trapping operation (originate from cotton growers)

- **C1.** Field not trapped
- **C2.** Not enough traps around the field
- **C3.** Poor spacing or placement of traps
- **C4.** Traps not serviced properly
- **C5.** Crop damaged by program vehicles

D. General program administration and management (originate from the general public and cotton growers)

- **D1.** Unprofessional behavior by program personnel
- **D2.** Disagreement with program policy, regulations, or their enforcement

KEY

Types of response, follow-up, and corrective action

1. Contacted person filing complaint, as soon as possible
2. Investigated by field supervisor
3. Investigated by USDA personnel (OIC, AOIC, PPQ Officer)
4. Referred to state regulatory personnel (complaint not related to SEBWEP)
5. Interaction/investigation with state regulatory personnel
6. Samples taken for residue analysis
7. Corrective action taken with pilot or aircraft
8. Chemical cleanup (spill or dump)
9. Reapplication due to inadequate treatment
10. Used ground equipment for pesticide applications
11. Changed timing of applications
12. Notified farmer of treatment dates
13. Sprayed field previously missed
14. Scouted field for weevil damage
15. Conducted weevil mortality tests
16. Installed traps
17. Increased number of traps
18. Improved spacing or placement of traps
19. Serviced traps
20. Trapper instructed to walk or use ATV
21. Counseled program personnel regarding behavior

Table 2-4. **Summary of types of complaints (continued)—Complaints received on SEBWEP—1987**

Type of complaint[1]	No. of complaints	Type of response, follow-up, and corrective action[2]	Valid complaints[3]
A1	7	1, 2, 3, 5, 6	4
A2	10	1, 2, 3, 6, 7, 12	7
A3	3	1, 3	
A4	7	1, 3, 5, 6, 7, 12	3
A5	1	1, 3	
A6	5	2	
A7			
A8			
A9			
A10	4	3, 10, 11	3
B1			
B2			
B3			
B4			
B5			
B6			
B7			
C1			
C2			
C3			
C4			
C5			
D1			
D2	2	3	
TOTAL	39		17

[1]See the list of types of complaints.
[2]See the list of types of response, follow-up, and corrective action.
[3]As determined by investigation, the complaint was related to SEBWEP.

Table 2-4. **Summary of types of complaints (continued)—Complaints received on SEBWEP—1988**

Type of complaint[1]	No. of complaints	Type of response, follow-up, and corrective action[2]	Valid complaints[3]
A1	3	1, 2, 3, 6	3
A2	7	1, 2, 3, 5, 6	5
A3	2	1, 3, 5	2
A4	4	2, 3, 6, 7, 10, 12	4
A5			
A6	2	1, 2, 3, 7	2
A7			
A8	1	1, 3	1
A9			
A10	3	3, 6, 7	3
B1	1	1, 2, 3, 12	1
B2			
B3	5	1, 2, 3, 12, 13	5
B4	3	2, 3, 11, 12, 14	3
B5	4	1, 2, 3, 6, 13, 14	4
B6	2	3, 12, 14	2
B7	6	2, 3, 10, 11, 14, 17	6
C1	6	2, 3, 16	6
C2			
C3	2	1, 2, 3, 19	2
C4	6	1, 2, 3, 12, 19	6
C5	4	1, 2, 3, 20	4
D1			
D2	2	2, 3, 11	2
TOTAL	63		61

[1]See the list of types of complaints.
[2]See the list of types of response, follow-up, and corrective action.
[3]As determined by investigation, the complaint was related to SEBWEP.

Table 2-4. Summary of types of complaints (continued)—Complaints received on SEBWEP—1989

Type of complaint[1]	No. of complaints	Type of response, follow-up, and corrective action[2]	Valid complaints[3]
A1	1	3, 6	1
A2	4	1, 3, 7, 10, 11	4
A3	2	2, 3, 5, 12	2
A4	1	2, 3, 5, 12	1
A5	1	1, 3	1
A6	2	1, 3	2
A7			
A8	1	3, 6, 10	1
A9			
A10	1	2, 11	1
B1			
B2	1	2, 7, 12	1
B3			
B4			
B5	1	1, 2	1
B6			
B7	6	2, 3, 11, 14, 16	5
C1	2	2, 3, 14, 16	2
C2			
C3			
C4			
C5	5	1, 2, 3, 20, 21	5
D1			
D2			
TOTAL	28		27

[1]See the list of types of complaints.
[2]See the list of types of response, follow-up, and corrective action.
[3]As determined by investigation, the complaint was related to SEBWEP.

Table 2-4. Summary of types of complaints (continued)—Complaints received on SEBWEP—1990

Type of complaint[1]	No. of complaints	Type of response, follow-up, and corrective action[2]	Valid complaints[3]
A1			
A2			
A3	3	3, 4, 6	1
A4	1	3, 6	1
A5			
A6	2	2, 3, 6	2
A7			
A8			
A9			
A10			
B1			
B2			
B3			
B4			
B5			
B6			
B7	1	2, 6	1
C1	3	2, 3, 16	3
C2			
C3	1	2, 16	1
C4	1	2, 19	1
C5	1	2, 21	1
D1			
D2	1	1, 2	1
TOTAL	14		12

[1]See the list of types of complaints.
[2]See the list of types of response, follow-up, and corrective action.
[3]As determined by investigation, the complaint was related to SEBWEP.

Alabama Program Operations. The eradication program began in the 21 southern Alabama counties in the fall of 1987 with 10 to 12 diapause applications of ultra low volume (ULV) Guthion®. The following spring, Guthion was replaced with ULV malathion.

Malathion is the only insecticide now used in the program area in Alabama. A ULV formulation is applied aerially on 98% of the acres treated. The other 2% of the acres are not suitable for aerial treatment; a ready-to-use (RTU) formulation is applied with high-clearance ground equipment on these acres. Pheromone traps in and around each field are monitored to determine the need for chemical treatment. In the 21-county program area, the threshold for malathion treatment is two weevils per field during the pinhead-square stage of cotton development and five weevils per field after the cotton blooms. Trappers work from the end of April until the end of November, with each responsible for servicing the traps on about 1,000 acres of planted cotton. Pheromone traps are placed either every 125 feet around the perimeter of the field or one trap per acre, whichever is greater. Traps are located on the field's edge from mid-July to mid-September and a few feet back from the field's edge before mid-July and after mid-September. This minimizes interference with cultivation and harvest.

Postharvest stalk destruction is mandatory in the program area. Timely destruction of cotton stalks is beneficial because it lessens the number of diapause treatments required, eliminates the boll weevil's food source, and prevents weevils from overwintering in unopened bolls. In past years of the program, growers have received credit against the next year's assessment if they destroy their stalks by a certain date. The dates of destruction and the amount of credit given vary from year to year and are determined by the Southeastern Foundation's Board of Directors in the late summer or early fall. The dates and credits are dependent on the number of insecticide applications that would have to be made if the stalks were not destroyed. For example, in the 1989 season, if stalks were destroyed by October 1, a credit of $7 per acre was given; by October 15, $5; by November 1, $3 per acre was given, according to a personal communication with Fred Planer (1990b).

Implementation of the National Boll Weevil Cooperative Control Program in Central and Northern Alabama

The existing organizational structure of the Southeast Boll Weevil Eradication Program, as previously described, is expected to remain unchanged during implementation of the National Boll Weevil Cooperative Control Program in central and northern Alabama, according to a personal communication with Fred Planer (1990a).

Control methods being considered for use in the program are discussed in the following subsections (table 2-5). Because volume 1 of the Draft EIS contains a detailed discussion of the control methods, not all of the information will be repeated here. However, the control methods for which new or updated information was available have been expanded to include that information.

Cultural Methods

Alabama's climate and growing conditions for cotton production vary from north to south. Some of the cultural techniques used in other areas of the Cotton Belt may not be successful in Alabama. Of the cultural control techniques discussed in the Draft EIS, only postharvest stalk

Table 2-5. Use of control methods in program regions in Alabama

Method	South	Central	North
Stalk destruction	1	1	1
Crop rotation	2	2	2
Trap cropping	3	3	3
Short-season cotton varieties	3	3	2
Voluntary production relocations	2	2	2
Mass trapping	3	3	3
Sterile insect release	3	3	2
Malathion	1	1	1
Diflubenzuron	2	2	2
Methyl parathion	2	1	1

Legend:
1 — Generally incorporated in the eradication program.
2 — Could have limited use in the eradication program.
3 — Not expected to be used in the eradication program.

destruction is widely used and expected to continue during the program's implementation.

Postharvest Stalk Destruction

In Alabama, growers use a bush-hog to destroy stalks. A bush-hog is a large mower with horizontal rotary blades that is pulled behind a tractor to shred the stalks to within 2 inches of the ground. Stalk destruction is already widely used, and growers will be required to continue the practice throughout the program's implementation.

Short-Season Cotton Varieties

Short-season cotton varieties do not produce well in Alabama because of the state's erratic rainfall. If it does not rain during the fruiting period, yield is low. Because regular-season cotton varieties have a longer fruiting period, the chance of rainfall during their fruiting period is much greater, according to a personal communication with Dr. Ron Smith (1990).

Crop Rotation

Cotton is the most valuable row crop in Alabama except for peanuts (Alabama Agricultural Statistics Service, 1988). However, the federal government strictly controls peanut allotments; therefore, crop rotation is limited to cotton growers who have peanut allotments and can alternate between the two crops. Crop rotation is not expected to be encouraged for program use because of the limited economic viability of alternative crops in Alabama.

Voluntary Crop Relocation

The program may encourage relocating cotton production from environmentally sensitive areas or areas difficult to treat either aerially or with ground equipment, to less sensitive areas. Growers would participate in crop relocation on a voluntary basis. However, most areas in Alabama suitable for cotton production are already used for that purpose, so any relocation would be on a small scale.

In some sensitive areas, growers may be prohibited from growing cotton. If cotton is planted in these areas, the state would have the authority to destroy it as a nuisance crop.

Mechanical Method

Mechanical control by mass trapping of boll weevils with pheromone traps, as discussed in the Draft EIS, will probably not be implemented in the Alabama program area because it is too labor intensive and does not provide an acceptable level of control for an eradication effort. Pheromone traps are currently used for monitoring purposes only.

Sterile Insect Technique

As more is learned from research about the biology and genetics of the boll weevil, the suitability of using sterile weevils in sterile-insect-release control programs becomes more feasible. Although releasing sterile boll weevils is not yet a practical means of controlling large boll weevil populations, it may be useful in fields with only small numbers of weevils, in fields near sensitive areas where chemical treatments are not appropriate, or in fields difficult to reach by ground equipment.

In 1987 a test was conducted comparing the survival, sexual attractiveness, and mating propensity of three strains of boll weevils that were sexually sterilized by radiation (North et al., 1988). The tested strains included the strain reared at the Gast Rearing Facility in Starkville, Mississippi; an improved strain of sterilized weevils; and a control strain from the Boll Weevil Research Laboratory. Each of the three strains of irradiated weevils lived longer in the field than those in the laboratory. In the laboratory, the improved strain had a 14-day postirradiation survival rate of greater than 90% and had a 70% mating propensity 10 days after sterilization. The sexual attractiveness to wild females varied for the strains in different stages of the life cycle, with the Starkville strain being most attractive the first 5 days and the improved strain being most attractive after 5 days and for at least 15 days after irradiation, as tested in the field.

In 1988 a sterile boll weevil release experiment was conducted in Lamar, Fayette, and Tuscaloosa Counties in Alabama (Smith et al., 1989). The ratio of sterile to native weevils was never more than 10:1 during the aerial release period, and a measurable level of suppression during the peak fruiting period was obtained. By midseason only a few fields had reached a treatment threshold level. The need for insecticide applications, including treatments for *Heliothis* spp. and other secondary pests, was greatly reduced over the entire test area.

Chemical Control

The chemicals available for use in the proposed program in central and northern Alabama are malathion, diflubenzuron, and methyl parathion. Based on economic and environmental

considerations, malathion would be used most often for aerial and ground applications.

Aerial Application

Training. All APHIS personnel must successfully complete a pesticide certification program before they can plan, manage, or supervise the application of program treatments in Alabama. The APHIS pesticide certification program consists of two parts: a fumigation workshop and a self-instructional course in pesticide application consisting of three documents—*The New Pesticide User's Guide*, a textbook covering most of the basic information presented in the training; *Pesticide User's Reference*, a reference containing PPQ guidelines and work-related suggestions about many aspects of pesticide use; and a *Participant Workbook*, an eight-lesson workbook containing the self-instructional part of the course. A score of 80% or higher is required to pass the examination. Certification must be renewed every 3 years (USDA, 1990).

EPA requires pilots of agricultural aircraft to be certified applicators if they are applying diflubenzuron or methyl parathion. Most states, including Alabama, also require certification of aerial applicators of malathion. Only certified applicators will be used in the cooperative control program.

The certified aerial applicators used by the program also receive additional training from USDA pilots. The USDA pilots help program personnel assess the condition of contract aircraft, and they routinely monitor contractor performance during aerial applications.

Operations. Fixed-wing aircraft or helicopters would be used in Alabama for aerial applications of ultra-low volume (ULV) spray formulations of malathion and diflubenzuron and a microencapsulated formulation of methyl parathion. High-volume aerial applications of program pesticides have been eliminated from the analysis despite lower drift volumes. The primary reasons for using ULV applications are lower program costs and longer periods of effective control. Compared to conventional spray formulations, significantly less ULV material is required to treat a given area. Thus, treatment aircraft can treat more acres in less time and use less fuel. Moreover, the effectiveness of ULV formulations is equal to or better than conventional methods.

Aerially applied insecticides are sprayed with special nozzles on spray booms mounted near the trailing edge of the aircraft wing. Swaths range from 60 to 125 feet, depending on the aircraft used. To minimize drift, insecticides will be applied 5 to 12 feet above the cotton canopy. If a field contains an obstruction, the aircraft may increase its spray altitude if the obstruction is not near a sensitive area or if it is not possible to use a ground application method for the area surrounding the obstruction.

Weather conditions are also a factor in determining when to conduct aerial applications. Some weather conditions may reduce the effectiveness of the operation or increase the potential for offsite drift or runoff. If the wind velocity is more than 10 miles per hour (mph) or if rainfall is imminent, aerial applications will be postponed or discontinued until conditions become more favorable.

Insecticide applications are monitored to determine whether all target areas have been treated satisfactorily and to determine whether another localized treatment is necessary. In areas where applications cannot be observed, oil-sensitive dyecards will be used to determine the uniformity and adequacy of applications. Dyecards may also be used to monitor the accuracy of applications near sensitive areas.

Ground Application

Where aerial pesticide applications are impractical or inappropriate, high-clearance ground equipment (hiboys) would be used. Mist blowers mounted on trucks would be used for treating the edges of fields not covered by aerial treatments because of trees or other obstacles. Ground equipment will be used on small fields, fields surrounded by trees, or fields near sensitive areas. The RTU formulation of malathion will be applied by hiboys, while mist blowers will apply the ULV formulation. Diflubenzuron and methyl parathion may be applied with either type of equipment.

Although stipulations about weather conditions are not as stringent for ground applications as for aerial applications, they are also considered when determining the timing of ground applications. If windspeeds exceed 15 mph or rainfall is imminent, treatments will be postponed until weather conditions improve.

Methods Eliminated From Detailed Study

Biological Control

There are no known effective predators, parasites, or microbial pathogens in Alabama to control the boll weevil. The major causes of mortality will vary among the regions infested. In a Texas field study, predation accounted for 58% of the mortality of immature boll weevils in the east-coastal region of Texas. Most of this mortality was attributable to the red imported fire ant (Sturm and Sterling, 1990). In the north-central region of Texas, the major causes of mortality were fairly equally divided among desiccation (30%), predation (23%), and parasitism (23%). The major parasitoid of the boll weevil was found to be the wasp, *Bracon mellitor*. As discussed in volume 1 of the Draft EIS, because of their lack of effectiveness, biological controls have been eliminated from the detailed analysis.

Attracticide

The Agricultural Research Service in Mississippi is developing an attracticide stick, which is a combination of a pheromone, a feeding stimulant, shellac, and an insecticide. This innovation may be useful in the future in areas where aerial spraying is prohibited and ground spraying is limited. It is still experimental and has not been proven in the field; therefore, it will not be considered in detail for use in the current program. However, if sufficient progress is made in developing this method, it may be considered for use later in the program.

Implementation of the Preferred Alternative—Eradication With Full Federal Involvement

The number of insecticidal treatments applied to infested acreage each season generally ranges from 4 to 11 during the program. Individual fields with exceptionally high numbers of weevils may receive up to 25 treatments. Boll weevil counts that would trigger a treatment would be similar to those used in the current program area: two per field

during the pinhead-square stage and five per field after the cotton blooms.

The proposed program (table 2-6), which would last an estimated 3½ years, would begin with a "modified" diapause treatment schedule consisting of five to seven applications of malathion or methyl parathion during the highest boll weevil movement period (September through October), with a possible treatment in November, depending on the severity of infestation and the dates of harvest and killing frost. The following June, year 2, two to four applications of malathion or methyl parathion would be made on 50 to 60% of the cotton acreage, beginning at the pinhead-square stage; traps would continue to be monitored to determine when treatments are necessary. It is estimated that between 2 and 10 treatments may be required.

During June and July of the second year, one to four treatments of diflubenzuron could also be used. In the fall of year 2, 6 to 11 diapause treatments would be applied to 50 to 60% of the acreage, depending on the remaining boll weevil populations. Two to four treatments on approximately 10 to 20% of the cotton acreage would be applied during the second spring, with trap monitoring continuing throughout the season to determine when additional treatments would be needed. Diflubenzuron could again be used during June and July. The final fall diapause treatments would consist of 6 to 11 applications on an estimated 40% or less of the cotton acreage. After 3 years of the control program, post-eradication monitoring would continue. If boll weevils are detected, localized treatments would be applied.

When the control program progresses to northern Alabama, diapause treatments may be eliminated the first fall because the colder winter temperatures contribute to higher winter weevil mortality than in the south and central regions of the state, and the larger cotton fields in the northern Alabama program area have fewer surrounding trees, which reduces weevil overwintering sites. In the spring, the program would begin with two to four applications on an estimated 30 to 40% of the cotton acreage. The rest of the northern program is likely to follow the same schedule as the central program area.

The Standard Operating Procedures adhered to in the current program area, which would also be implemented in the proposed program in central and northern Alabama, are listed in table 2-7; a summary of the impacts of the program implementation is presented in table 2-8.

No Action

If the grower referendums are not held or do not pass and the program does not progress to central and northern Alabama, an eradication buffer zone would be implemented with sufficient spot treatments and monitoring to protect the 21 counties in the current program from infested counties in the rest of the state. APHIS would neither fund nor participate in any program to control boll weevils in those regions of the state, and the current grower practices described earlier in this chapter would be expected to continue, as would the cultural treatment methods of fairly uniform planting dates and stalk destruction. Growers would continue to scout their fields for all pests and bear the entire cost of all necessary insecticide treatments. Though it may be possible to control the boll weevil and other insect pests at subeconomic levels under this alternative,

Table 2-6. Pesticide application schedule for proposed expansion of boll weevil eradication program

Year	Central Alabama		Northern Alabama	
	Average schedule	Maximum schedule	Average schedule	Maximum schedule
		Malathion or Methyl Parathion		
First year:				
September	2	4	--	2
October	3	3	--	3
November	--	1	--	--
Second year:				
June	3	4	3	4
July	1	5	--	5
August	1	5	--	5
September	3	5	4	5
October	2	4	3	4
November	1	2	1	2
Third year:				
June	3	4	3	4
July	1	5	--	5
August	1	5	--	5
September	3	5	4	5
October	2	4	3	4
November	1	2	1	2
		Diflubenzuron		
Second year:				
June	2	3	2	3
July	--	1	--	1
Third year:				
June	2	3	2	3
July	--	1	--	1

it would not be possible to use a more integrated approach to pest management, that is, one using natural parasites and predators and other nonchemical controls that could be used if the boll weevil were eliminated. It is likely that present levels of insecticide applications will continue to be required for economic cotton production.

The analysis of impacts presented in chapter 4 is based on a comparison of the possible effects from implementing the National Boll Weevil Cooperative Control Program in central and northern Alabama to the current agricultural environment of cotton production as it is described under the no action alternative.

Integrated Pest Management

Integrated Pest Management (IPM) is an approach to cotton pest management that uses several techniques, including cultural practices, the selective use of pesticides, field surveys, the use and protection of beneficial insects, and diapausing boll weevil control (Alabama Cooperative Extension Service, 1990). One hundred percent participation by the grower community is essential to the success of an IPM program.

The goal of IPM programs is to suppress insect populations below damaging economic levels, not reduce them to zero. Insecticides are not used until the cost of the damage the insect causes exceeds the cost of the insecticide and application necessary to control it. Intense field scouting is important in determining when insect populations reach the economic threshold. Economic thresholds vary depending on several factors, including weather conditions (temperature and rainfall influence the plant's tolerance to insect damage); the presence of beneficial insects (a high or increasing number can increase the threshold level); the field's treatment history; the field's yield potential (the economic return for the same treatment may vary from field to field); and the combination of pests present (several pests, although each may be below economic thresholds, can add up to damaging levels) (Alabama Cooperative Extension Service, undated).

The presence of boll weevils in Alabama makes a true IPM strategy for cotton insect pests infeasible. The relatively warm winters, the availability of overwintering sites, and the lack of known biological and other effective nonchemical controls enable the boll weevil to be an economic pest for the entire growing season, one that requires the continued use of broad-spectrum insecticides. This continued use of broad-spectrum insecticides also depletes populations of beneficial insects and necessitates the use of other insecticides to control the remaining cotton insect pests. However, an integrated control strategy can be used with some success. A single treatment at the early spring pinhead-square stage (late May or early June) timed to kill overwintered weevils before they lay eggs can be very effective in controlling boll weevils. By avoiding multiple treatments, beneficial insects have an opportunity to reestablish themselves, thereby helping to control other pests. Then no weevils should appear until early July, and four or five treatments should result in sub-economic levels of weevil infestation for the rest of the season, according to a personal communication with Dr. Ron Smith (1990).

Table 2-7. Standard operating procedures

All Control Methods

1. All applicable federal, state, and local environmental laws and regulations will be followed during boll weevil control operations.

2. All required state and local authorities will be notified when the program begins. The notification will advise state and local authorities of the need to help identify sensitive areas in the proposed treatment areas.

3. All control operations will be conducted with appropriate concern for their potential impact on the endangered, threatened, and proposed species identified in this document.

   a. APHIS will prepare a biological assessment for federally listed endangered, threatened, and proposed species found within all U.S. cotton-producing counties from species information provided by the U.S. Department of the Interior, Fish and Wildlife Service (FWS).

   b. Adequate protection measures will be developed for federally listed endangered, threatened, and proposed species through the Endangered Species Act, section 7, formal consultation with the FWS. Clarification of specific biological and distributional data will be accomplished in local-level Plant Protection and Quarantine (PPQ) conferences with local offices of FWS before operations begin.

   c. Species and habitats protected by state laws will be addressed as needed in site-specific assessments.

4. Sensitive areas (water bodies, parks, occupied dwellings such as homes, schools, churches, hospitals, and recreation areas) that may be in or adjacent to cotton fields will be identified. The program will be adjusted accordingly to ensure that these areas are not negatively impacted.

5. Only fields meeting the program criteria will be treated.

6. All program personnel will be instructed in use of equipment and materials and on procedures. Field supervisors will emphasize these procedures and monitor workers.

Chemical Control Methods

1. All program personnel will be instructed in emergency procedures to follow in the event of pesticide exposure. Equipment necessary for immediate washing procedures must be available.

2. Program personnel observing applications of malathion are required to wear protective clothing. Program personnel observing applications of methyl parathion are required to wear protective clothing and remain inside a closed vehicle with recirculating air.

3. Local beekeepers will be notified of program procedures and treatment intervals and informed of measures they can use to protect their bees.

Aerial Applications

1. All materials will be applied in strict accordance with EPA- and state-approved label instructions.

2. Aircraft, dispersal equipment, and pilots that do not meet all contract requirements will not be allowed to operate.

Table 2-7. Standard operating procedures (continued)

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3. All USDA—APHIS-PPQ employees who plan, supervise, recommend, or perform pesticide treatments must be certified under the APHIS certification plan. They also are required to know and meet any additional requirements or qualifications of the state in which they perform duties involving pesticide use.

4. Unprotected workers will be advised of the respective reentry periods following cotton field treatment.

5. All mixing, loading, and unloading of insecticides will be in an area where an accidental spill will not contaminate a stream or other body of water.

6. All insecticides will be stored in accordance with local and state regulations.

7. In the event of an accidental spill, procedures set forth in PPQ Guidelines for Managing and Monitoring Pesticides Spills (USDA, 1983b) will be followed.

8. Two-way radios will be provided to personnel who direct or coordinate field operations. Radio communication will be available to provide close coordination of all application operations.

9. Flags or other markers will be used in areas without natural landmarks for pilot guidance.

10. Application operations will be postponed in fields occupied by workers.

11. To the degree possible, pesticides will be delivered and stored in sealed bulk tanks and then pumped directly into the aircraft.

12. All insecticide drums must be triple rinsed before disposal. Rinse solutions may be used to prepare spray tank mixes or may be stored for subsequent disposal in accordance with label instructions. For drum disposal, operators must take one of the following steps:

    a. Require chemical companies, distributors, or suppliers to accept empty triple-rinsed drums.

    b. Transfer the empty triple-rinsed drums to state cooperators.

    c. Crush or puncture the empty triple-rinsed drums and dispose of as scrap metal.

13. All APHIS field personnel will have baseline cholinesterase tests before the first application and each spring and fall thereafter. It is recommended that contract, state, and other nonfederal personnel also participate in this testing program.

14. The program will employ only certified aerial applicators familiar with local conditions.

15. Pilots, loaders, and other personnel handling pesticides will be required to wear safety equipment and protective clothing.

16. To minimize drift and volatilization, application will not be made when any of the following conditions exist in the spray area: wind velocity exceeds 10 mph (unless lower windspeed is required by state law); rain is falling or is imminent; weather is foggy; air turbulence could seriously affect the normal spray pattern; or temperature inversions could lead to offsite movement of spray.

Table 2-7. **Standard operating procedures (continued)**

17. Oil- or water-sensitive dye cards will be used to regularly monitor application efficacy. Spray deposition in the target area and droplet size are critical concerns.

18. Nozzle types and sizes, spray system pressure, and nozzle orientation will be as specified in the program's aerial application contract or as otherwise directed by program personnel. Some of the contract specifications required for aerial application include:

    a. The use of stainless steel nozzles to minimize wear

    b. The use of diaphragm check valves in the nozzles for drip-free shut off with minimum pressure loss

    c. Requirement for a shut-off valve between the hopper and pump to prevent the accidental loss of pesticide in the event of a pump failure

    d. Requirement that the end nozzles be placed no more than three-quarters of the overall wing-span to minimize the amount of spray entering the wing tip vortices. If boom extends beyond three-quarters of the wingspan, end nozzles must be fitted with an air bleed line to prevent air entrapment in the boom and to allow positive shut off.

Ground Applications

1. Mist Blowers

    a. Operators will be either certified applicators or will be in constant radio contact with certified applicators.

    b. Units will be operated from closed truck cabs, with operators using recirculated air.

    c. Operators will wear appropriate safety equipment when loading and servicing the unit and will be specially trained by program personnel.

2. High-Clearance Machines

    a. Operators will be either certified applicators or will be in constant radio contact with certified applicators. Operators must be certified applicators for methyl parathion applications.

    b. Units will be operated from closed cabs, with operators using recirculated air.

    c. Operators will wear appropriate safety equipment and protective clothing when loading, servicing, and operating the unit.

    d. Operators will exercise extreme caution when applying methyl parathion.

Table 2-8. Summary of potential environmental impacts by control method

Resource element	Stalk destruction	Malathion	Diflubenzuron	Methyl parathion
Geology and topography	No impact.	No impact.	No impact.	No impact.
Climate	No impact.	No impact.	No impact.	No impact.
Soils	No impact.	Short-term reduction in some soil insects and arachnids.	No impact.	No impact.
Vegetation[a]	Indirect impact on adjacent crops by driving nonhost-specific pests into them.	Slightly phytotoxic to some vegetation. Indirect impact on plant reproduction because of some loss of pollinators.	No impact.	Indirect impact on plant reproduction because of some loss of pollinators.
Nontarget terrestrial species[a]	No impact.	Generally safe for use with respect to terrestrial species except for insects such as the honey bee.	Safe for terrestrial wildlife; not likely to affect bees.	Safe under normal circumstances of exposure, but would affect animals that are directly sprayed and feed exclusively on insecticide-contaminated food.
Nontarget aquatic species[a]	No impact.	Would likely affect bluegills, painted turtles, walleyes, and invertebrates if farm ponds or streams are contaminated from drift or runoff.	Not likely to affect aquatic species.	Not likely to affect fish, clams, aquatic reptiles, or amphibians. Some aquatic invertebrates may be at risk.
Water quality	No impact.	Possible short-term impacts in farm ponds and small streams.	Possible short-term impacts in farm ponds and small streams.	Possible short-term impacts in farm ponds and small streams.

Table 2-8. Summary of potential environmental impacts by control method (continued)

Resource element	Stalk destruction	Malathion	Diflubenzuron	Methyl parathion
Human health and safety—public	No impact.	No risk from typical exposure. No reproductive risk. Moderate risk of systemic effects as a result of direct spray, drinking 2 liters of contaminated water, or eating directly sprayed legumes. Cancer risk less than 1 in 1 million.	No risk from typical exposure. Cancer risk less than 1 in 1 million.	No risk from typical exposure. Risk to those exposed to drift within 100 ft of a cotton field or from eating contaminated berries or legumes near the site. Significant risk of systemic effects and moderate risk of reproductive effects from direct spray, drinking contaminated water, or eating berries or legumes that were directly sprayed.

Table 2-8. Summary of potential environmental impacts by control method (continued)

Resource element	Stalk destruction	Malathion	Diflubenzuron	Methyl parathion
Human health and safety—worker	No impact.	Risk to hiboy and mist blower operators in routine applications. Moderate risk of systemic effects to observer/environmental evaluation team, significant risk of systemic effects to hiboy and mist blower operators, and moderate risk of reproductive effects to hiboy operators from extreme exposure. Significant systemic and reproductive risk from accidents. Cancer risk to hiboy and mist blower operators.	Risk to hiboy and mist blower operators in routine applications. Moderate risk of reproductive effects to hiboy and mist blower operators from typical exposures. Significant systemic and reproductive risks to hiboy operators, and significant systemic and moderate reproductive risk to mist blower operators from extreme exposure. Significant systemic and reproductive risk from accidents. Cancer risk to hiboy and mist blower operators.	Risk to hiboy and mist blower operators in routine applications. Risk to aerial applicators in routine applications. Moderate reproductive risk to observer/EE team, and significant reproductive risk to hiboy and mist blower operators from routine exposure. Moderate systemic risks from extreme exposures to mixer/loaders; moderate reproductive risk to pilots and observer/EE team; significant systemic risks to pilots, observer/EE team, and hiboy and mist blower operators; and significant reproductive risk to hiboy and mist blower operators.

[a]Impacts on individual endangered, threatened, or proposed plant, wildlife, and aquatic species are assessed separately. Full assessment and protection measures are presented in appendix B.

Mitigation

Mitigation measures are provided in table 2-1 of the Draft EIS. In addition to those measures described in the table, azinphos-methyl will not be used in Alabama.

Limitations of the Analysis

This section discusses the possibility and consequences of the failure to eradicate and scientific information contrary to any of the assumptions, conclusions, or objectives set forth in the document.

Risk is always associated with any attempt to control or eradicate a pest. Moreover, control activities cannot be guaranteed to produce the desired results. The boll weevil eradication program is no different. Program experience indicates that eradication is an achievable goal; however, it is possible that the program could fail.

Failure to eradicate the boll weevil could have several of the following consequences:

- The establishment of permanent buffer zones to prevent reinfestation.
- Previously eradicated areas would have to be protected indefinitely.
- If cotton growers in the buffer zones withdrew their support for area-wide boll weevil control, the buffer zones would have to be moved into previously eradicated areas.
- Eventually, all the eradicated areas could be reinfested.
- The benefits of boll weevil eradication in Virginia, North and South Carolina, Georgia, southern Alabama, California, Arizona, and New Mexico would be lost.
- Each cotton grower would revert to an "every man for himself" approach to pest control. As history has clearly demonstrated, weevils reared on the few poorly managed farms would again infest all the farms in the nearby community.
- Insecticide use would likely increase, returning to pre-eradication levels as areas become reinfested.
- The total amount of pesticide used and the number of compounds used would almost certainly increase if the boll weevil is not eradicated.

Additional information about the consequences of program failure is available in "Cotton Boll Weevil: An Evaluation of USDA Programs," by National Academy Press, 1981. (p. 58-103).

Chapter 3

Affected Environment

Overview

The parts of Alabama that could be affected by implementing the National Boll Weevil Cooperative Control Program in central and northern Alabama include cotton fields as well as adjacent nonagricultural areas.

Chapter 3 of the Draft EIS, volume 1, describes the environment of all Cotton Belt states. The information presented in this chapter is intended to supplement the general information for Alabama included in descriptions of the coastal subarea of the Southeast program area presented in volume 1.

The natural and human environments vary across Alabama. Physical characteristics, such as topography and soils, and biological parameters, such as the presence of endangered and threatened species, differ from one area of the state to another. This chapter describes the potentially affected environment in Alabama for the following resource elements: geology and topography, climate, soils, vegetation, nontarget species, water resources, human populations, economics, cultural and visual resources, air quality, and the noise environment.

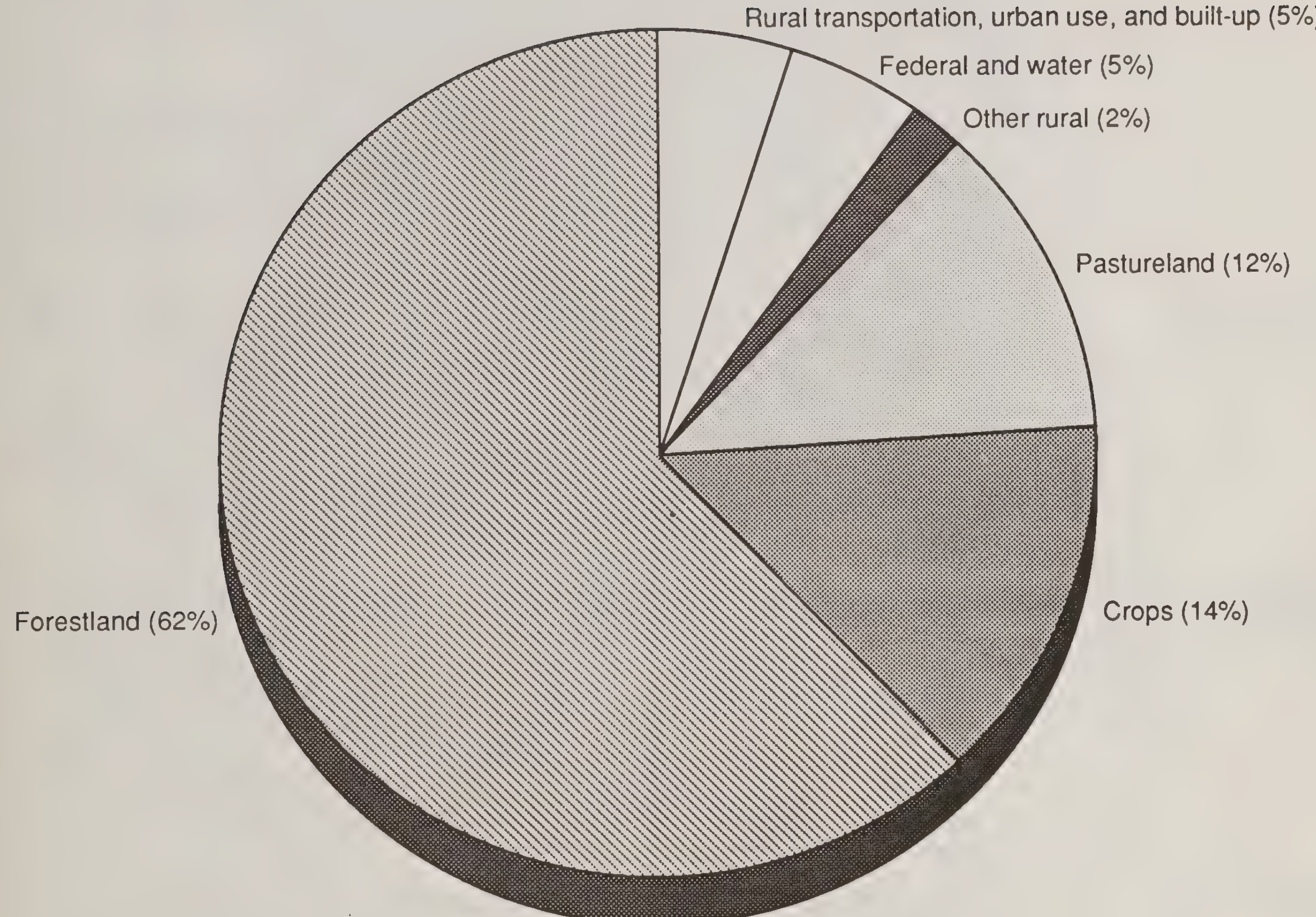
Alabama is located in the southeastern United States, bounded on the north by Tennessee, on the east by Georgia, on the south by Florida and the Gulf of Mexico, and on the west by Mississippi (fig. 3-1). Alabama's roughly rectangular area of 33.1 million acres (1.7% of the area of the continental United States) comprises 32.5 million acres of land (98% of the state's total area) and 0.6 million square miles of water (2%) (USDC, 1990). Rural areas supporting forests and agriculture constitute approximately 90% of the total land area of Alabama, or about 27 million acres (USDC, 1990).

Before settlement, Alabama was covered with primeval pine and hardwood forests and constituted one of the world's greatest timber regions (Walker, 1975). Despite intensive logging, 21 million acres of forest land still occupy 62% of the state (fig. 3-2) (USDC, 1990). Many state parks, National Forest Recreation Areas, game management areas, and wildlife refuges are located in these forested areas (Alabama Department of Economic and Community Affairs, 1989). Over time, parts of the forest land have been cleared for cropland, pastureland, transportation routes, and urban development (USDC, 1990).

The greatest proportion of agricultural lands are in the northern, west central, and southeastern areas of the state. These agricultural lands support a variety of livestock, dairy, poultry, and field crops (ADECA, 1989). Cropland represents 14% of the state's area (4.5 million acres); approximately 7% of this cropland is planted with cotton. Other principal field crops include soybeans, winter wheat, corn, peanuts, and sorghum. Hay, oats, peaches, pecans, and sweet potatoes are also grown (ADAI, 1990).

Fig. 3-1. Location of Alabama

Fig. 3-2. Land uses in Alabama



Note: Shaded portions represent rural areas (90% of Alabama).

Source: USDC, 1990.

Minerals found in the state include bauxite, asphalt, clay, mica, marble, salt, and petroleum (Hammond, 1981). Deposits of coal, iron ore, and limestone—the ingredients for making steel—led to the development of iron and steel manufacturing in the eastern part of Alabama (Walker, 1975). The manufacture of aluminum, chemicals, fertilizers, metal and rubber products, and textiles are the predominant industries in northern Alabama. In southern Alabama, industries primarily manufacture metal products, machinery, cement, paper products, and chemicals (Hammond, 1981).

Commercial fishing is also an important activity in southern Alabama; crabs, shrimp, oysters, and mullet are the main species caught in the Gulf of Mexico (USDC, 1990). Ponds throughout the state support catfish hatcheries. Alabama's lakes and rivers are used for commercial and recreational fishing, as well as for boating and other water sports.

Geology and Topography

Alabama can be divided into four physiographic regions: the Appalachian Plateau, ridge and valley, Piedmont, and coastal plain (fig. 3-3). The state is mountainous in the northeast, where spurs of the Appalachian Mountain range enter from Tennessee. From an elevation of 1,800 feet, the land drops sharply northwest to the Tennessee Valley and then slopes gradually toward the south until it reaches sea level. Westward, the land shelves in a gradually diminishing range of hills (Walker, 1975). The average state elevation is 250 to 500 feet above sea level (Nomad, 1986).

Appalachian Plateau (Cumberland Plateau)

The Appalachian Plateau, known as the Cumberland Plateau in Alabama, Tennessee, and Kentucky, is underlain by horizontal sediments of the upper Paleozoic Age. The Tennessee Valley (in the northern part of this region) is a relatively level section of about 4,900 square miles on both sides of the Tennessee River. The naturally productive soils in this valley have made it Alabama's primary cotton-producing area (Walker, 1975). Elevations in the Appalachian Plateau range from approximately 1,000 feet in the floodplain of the Tennessee River to 700 feet in the southern part of the region.

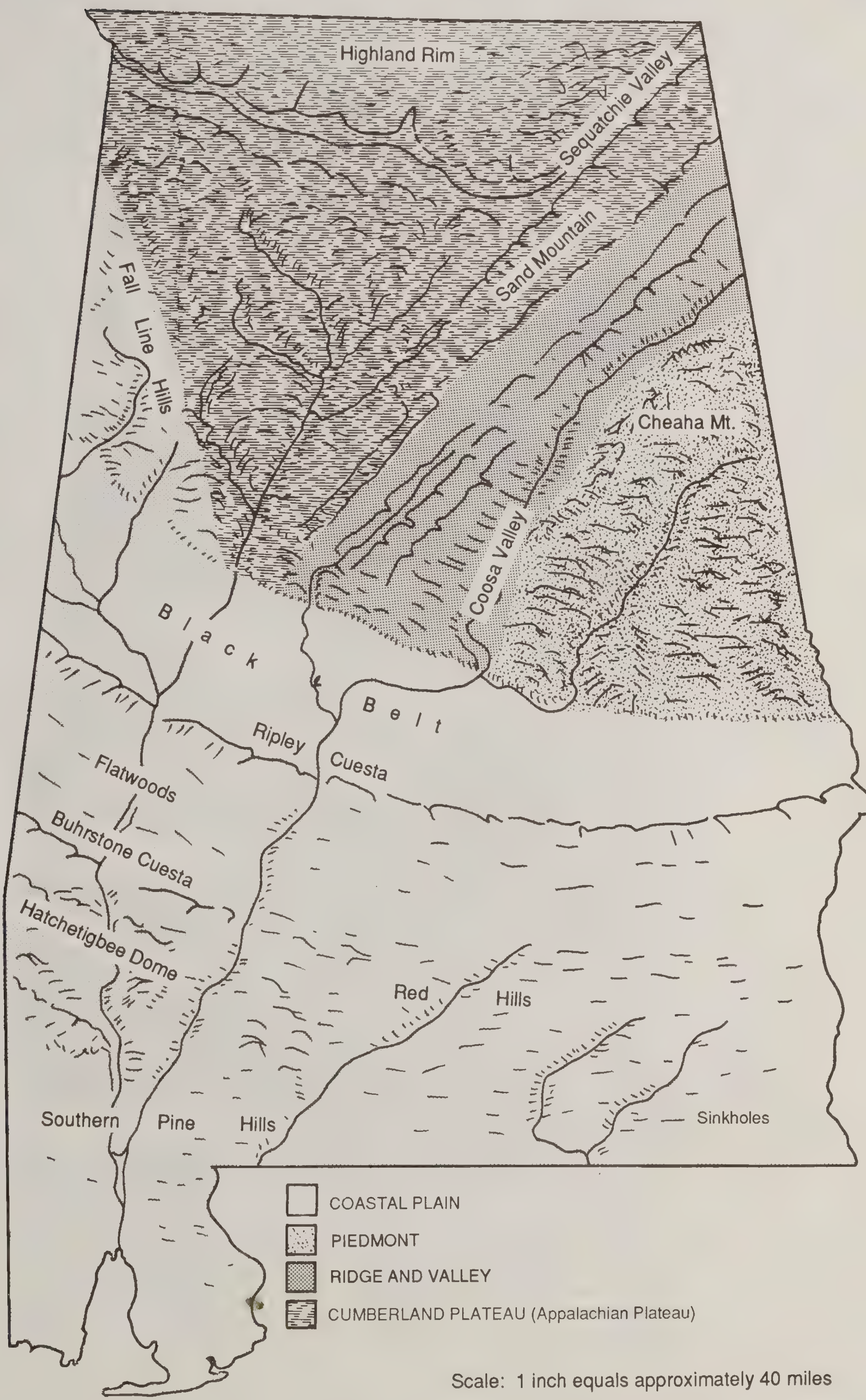
Ridge and Valley

The ridge and valley region in Alabama, underlain by Paleozoic sediments, consists of a series of parallel ridges and valleys running northeast to southwest. The narrow ridges are a continuation of the Appalachian Mountain chain, which enters the state in the northeast corner. The Coosa Valley is more rugged and less suited to agriculture than the Tennessee Valley (Walker, 1975). Elevations range from 1,200 to 1,800 feet along the ridges and mountains, to 500 feet in the wide lowland area drained by the Coosa River.

Piedmont

The Piedmont region is underlain by igneous and metamorphic rocks of the Precambrian and Paleozoic ages. Most of the region is composed of small rolling hills at elevations of 700 to 1,000 feet, with streams occupying the valleys (Lineback and Traylor, 1973). Mount Cheaha, the highest peak in the state, is located in the Talladega Hills, where elevations range from 900 to 2,407 feet. These areas are too steeply sloping for agriculture; most rolling areas are used as pasture or forest (Mitchell and Meetze, 1986).

Fig. 3-3. Physiographic regions of Alabama



Source: Adopted from Erwin Ratsz;
as cited in Lineback and Taylor, 1973.

Coastal Plain

The coastal plain is underlain by relatively unconsolidated Mesozoic and Cenozoic sedimentary rock, which dips toward the Gulf of Mexico. Chalk of the Cretaceous age underlies the Black Belt, a strip of rolling prairie land with rich black soil. This 4,300-square-mile area was the chief cotton-growing area of Alabama, but it is now used primarily for soybeans, timber production, and pasture (Mitchell and Meetze, 1986). Below the Black Belt, a low line of hills (cuestas) are separated by lowland areas. Elevations range from 200 to 300 feet in most of the plain to sea level at the coast. The coastal plain is the largest agricultural area in Alabama, although it does not support the highest cotton production in the state (Walker, 1975).

The northern border of the coastal plains marks the contact between the crystalline rocks of the Piedmont and the sedimentary rocks of the coastal plains. This irregular boundary is referred to as the fall line of the Atlantic states.

Climate

Alabama's climate is humid and subtropical, with precipitation distributed throughout the year. Summers are hot and humid, with little variation in temperature from day to day. The winters are relatively mild, and severely cold or snowy periods seldom occur. Temperatures below zero are rare, occurring on an average only once in 6 to 7 years (Ruffner, 1978). Precipitation is heaviest along the gulf coast during summer and heaviest in the northern sections of the state during winter. Thunderstorms are common during the summer, and tropical hurricanes occasionally reach the gulf region (Ruffner, 1978).

Temperatures

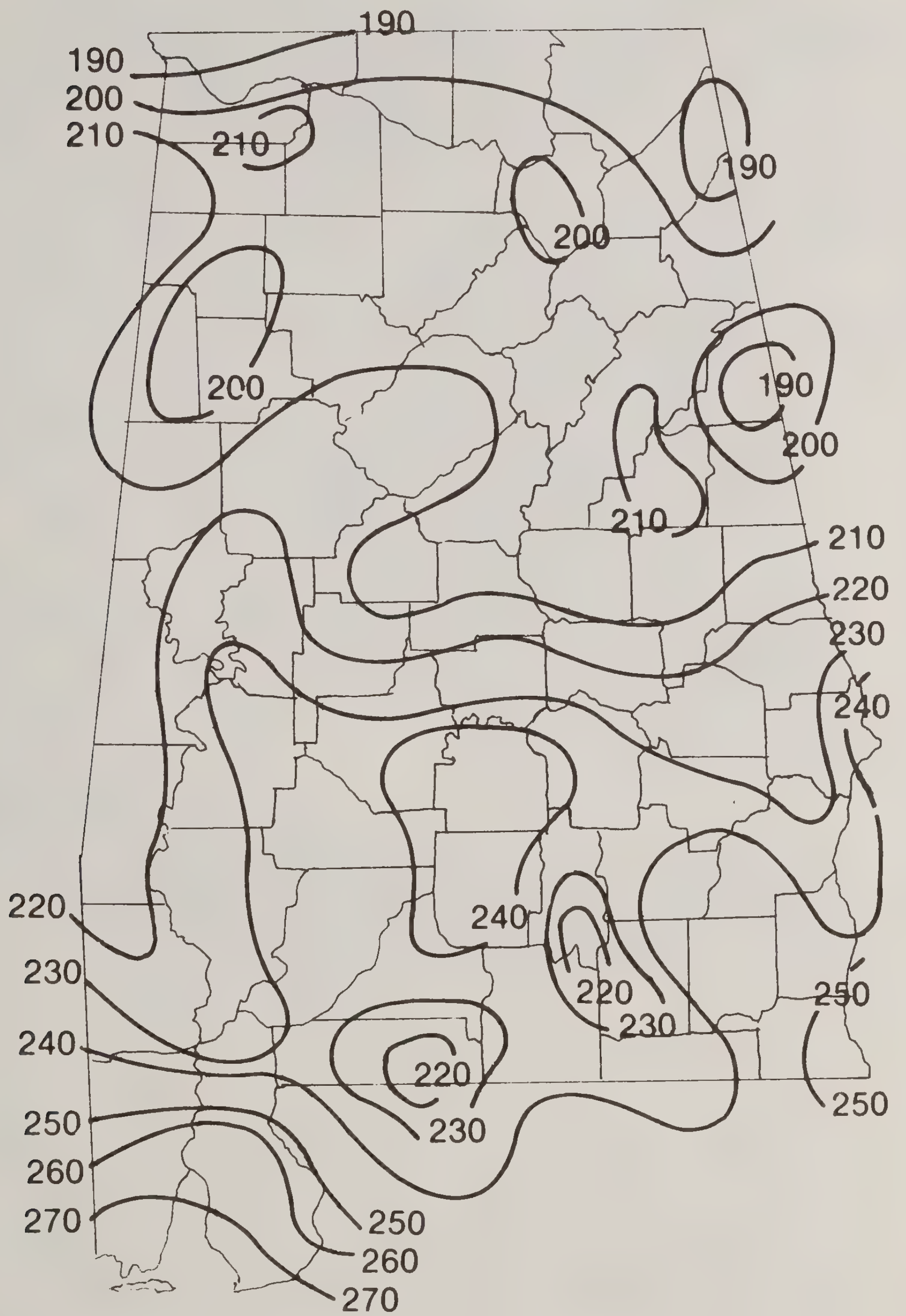
During the winter months northern Alabama is cooler than the southern part of the state. Temperatures during January, the coldest month, average 40°F in the north and 50°F in central and southern Alabama (ADECA, 1989). The first killing frost generally occurs at the end of October in the north, the beginning of November in the central and south, and the beginning of December along the gulf coast. Temperatures below freezing usually last less than 48 hours (Lineback and Traylor, 1973).

During July, the hottest month, daily temperatures in the average 80°F throughout the state (ADECA, 1989). The last killing frost in the spring usually occurs by the beginning of April in the northern part of the state, the end of March in the central part, mid-March in the south, and mid-February along the gulf coast. The date of the last killing frost marks the beginning of the growing season; because winter frosts end earlier in the south, that area has a longer growing season. The growing season ranges from 190 to 210 days in the north, 200 to 240 days in central Alabama, and from 220 to 270 days in the south (fig. 3-4).

Precipitation

Precipitation varies slightly geographically. The mean annual precipitation for selected regions of the state is 54 inches in the north and central regions (Appalachian Mountains and upper plains), 56 inches in the south (coastal plains), and 65 inches along the gulf. However, the timing of the precipitation varies considerably among the different areas. The greatest monthly levels of precipitation for north and central Alabama occur in March, while the south receives the most monthly precipitation in July (USDC, 1968).

Fig. 3-4. Average length of growing season in Alabama (days)



Source: ADECA, 1989.

During the hot summer months, most precipitation results from afternoon thundershowers (Ruffner, 1978). These summer thundershowers provide sufficient moisture for crops (Lineback and Traylor, 1973). Except for the coastal region, where late night and early morning thundershowers persist until mid-September, the frequency of thundershowers decreases during the late summer months, and dry, sunny conditions usually prevail in September and October. Tropical hurricanes reach the state on an average of 1 in 7 years between July and November, often causing heavy rains and high winds (Ruffner, 1978).

Precipitation in the state is almost always in the form of rain, and the annual average of snow is 3 inches in winter. The north has 2 to 3 days each winter with measurable snowfall, the central and south have 1 day every 2 to 3 years (Lineback and Traylor, 1973).

Soils

Variations in topography, climate, and age affect soil characteristics. For example, the well-drained moderate slopes found in humid subtropical areas, such as Alabama, contribute to the formation of mature soils with well-developed topsoil. These soils are well suited for agriculture (Lineback and Traylor, 1973).

Four groups of soil orders are represented in the state: ultisols, inceptisols, entisols, and vertisols. The characteristics of these soil orders are provided in chapter 3 of the Draft EIS, volume 1. The state may be further divided into seven regions, which display similar soil characteristics (fig. 3-5). The general characteristics of each region are described in the following sections.

Limestone Valleys and Uplands

Soils in the limestone valleys have been formed from limestone, which has been extensively eroded over time. The Tennessee and Coosa River Valley soils are representative of this region and are characterized by red clay subsoils and surface soils composed of silt loam. Soils in the uplands were primarily derived from the erosion of cherty (flinty) limestone. These soils typically have a cherty loam and cherty clayey subsoil, and cherty silt loam surface layers. Soils are used for row crops, such as cotton and soybeans, and much of the area is pasture or forest land.

Appalachian Plateau

Most of the soils are derived from sandstone or shale. These soils have either a loamy or clayey subsoil and a silt-loam surface layer. The more level areas of the Plateau are dominated by soils formed from the erosion of sandstone. These areas are characterized by loamy subsoils and fine sandy loam surface layers. Corn, soybeans, potatoes, and tomatoes are the main crops of the Appalachian Plateau. Poultry is also important in this area.

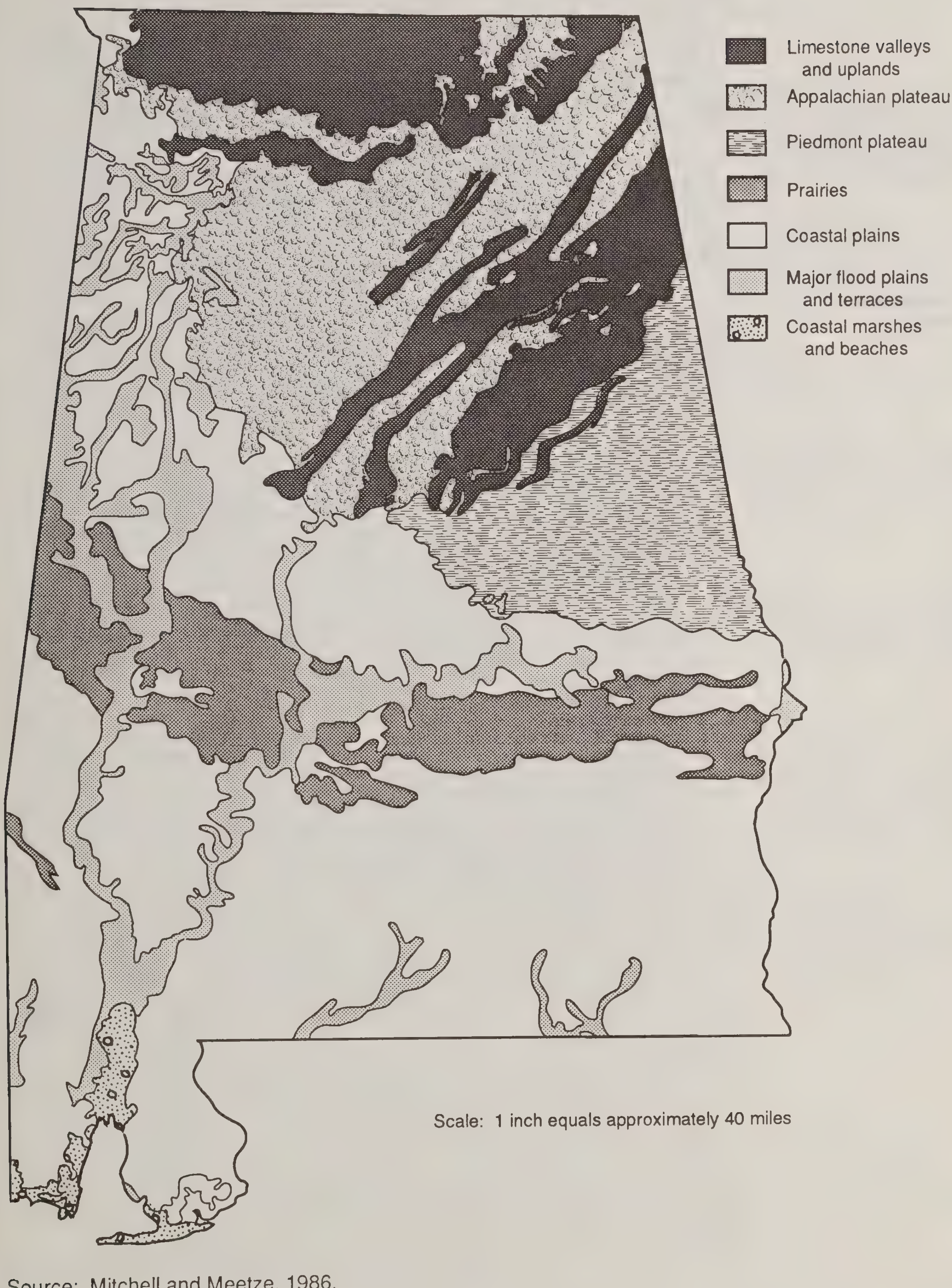
Piedmont Plateau

Most of the soils in this region are derived from schists, characterized by red clayey subsoils and sandy loam and clay loam surface layers. The rolling areas were once cultivated but are now in pasture or forest.

Coastal Plains

The coastal plain is characterized by either loamy or clayey subsoils and sandy loam, loam, sand, or loamy sand surface layers. Most of the soils in this region are derived from marine and river sediments eroded from the Appalachian and Piedmont Plateaus. Major crops are corn, peanuts, soybeans, and horticultural crops. Timber products and hogs are also prevalent.

Fig. 3-5. Soil areas of Alabama



Source: Mitchell and Meetze, 1986.

Prairies

These soils were derived from alkaline, Selma, chalk, or acid marine clays. Most soils in this region are acidic, poorly drained, and contain a large percentage of montmorillonitic clays, which shrink and crack when dry, and swell when wet. This area of central and western Alabama is known as the "Black Belt" because of the dark surface colors of many of the soils. Soybeans are the principal crop. Most of these soils are used for timber production and pasture.

Major Flood Plains and Terraces

The soils in this region are found along streams and river terraces. They are derived from alluvium, which has been deposited by streams during their normal flow and when excessive precipitation causes flooding. A typical area consists of cultivated crops on the level terraces and bottomland hardwood forests on the floodplain of streams.

Coastal Marshes and Beaches

The soils in this region are found only on nearly level bottomlands and tidal flats along the Mobile River, Mobile Bay, and the Gulf of Mexico. The soils may be broken down into four types—muck surface layers over sand; mucky sandy, clay loam surfaces over sandy loam subsoil; silty clay loam over clay; and sand that overlies other types of sand (Mitchell and Meetze, 1986).

Vegetation

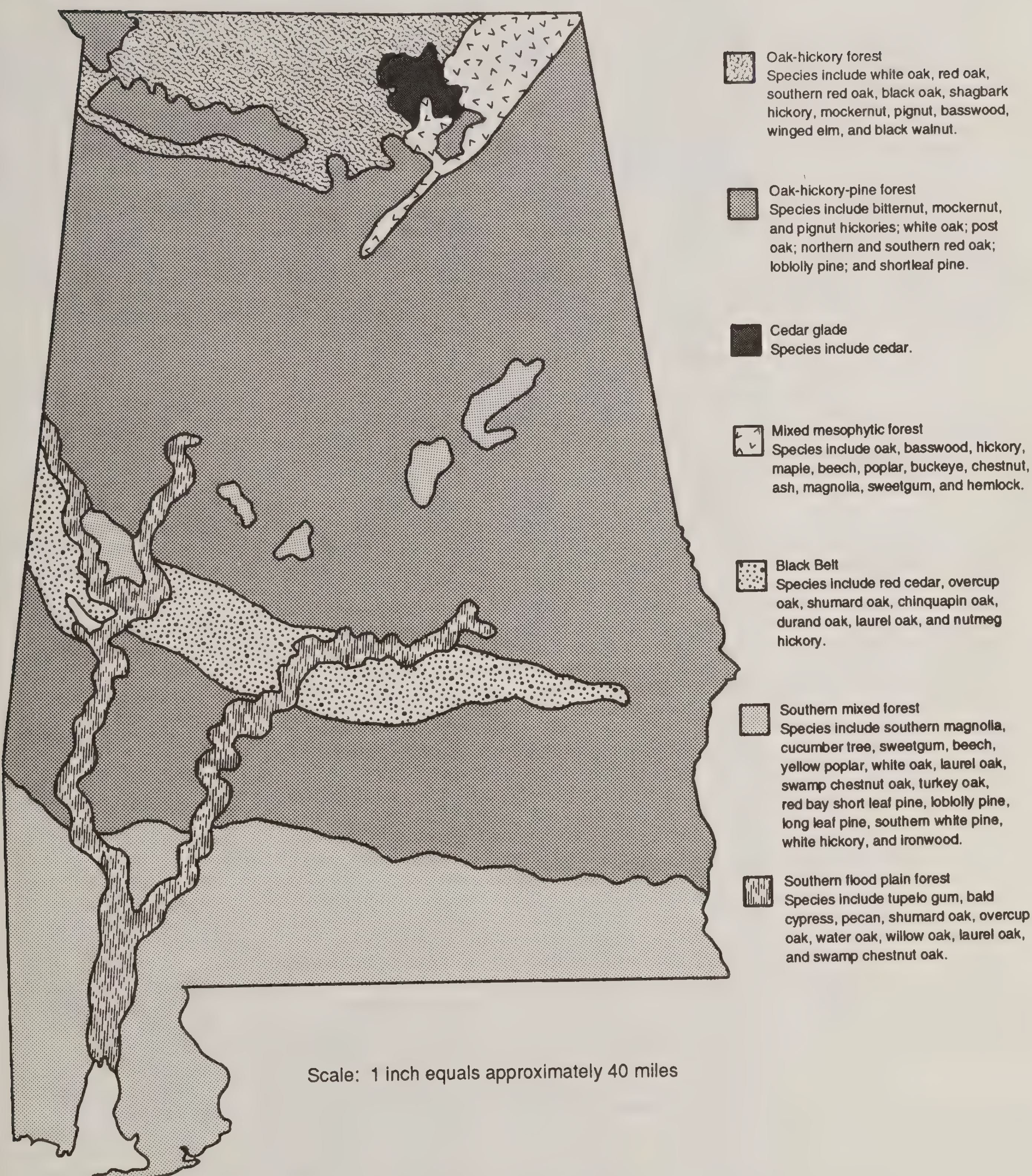
Alabama's natural vegetation changes as the region, elevation, rainfall, and soil type change across the state. Throughout Alabama, the natural, undisturbed vegetation type is forest. Types of forests found in Alabama include the oak-hickory forest, the mixed mesophytic forest, the oak-hickory-pine, and the southeastern mixed forest (fig. 3-6).

Plant Communities

In the extreme north central and northwestern areas of the state, the oak-hickory forest is the dominant plant community. This forest type, which also covers much of the central midwestern United States, is characteristic of relatively dry sites. The dominant tree species in this forest are white oak, red oak, southern red oak, black oak, shagbark hickory, mockernut, and pignut. Basswood, winged elm, and black walnut also are commonly found in the oak-hickory community (Lineback and Traylor, 1973).

In the northeastern corner of Alabama, adjacent to the oak-hickory forest, the southern terminus of the Appalachian highlands forms moist, cool ravines where the mixed mesophytic forest is the dominant plant community. Several different species of oak, basswood, hickory, maple, beech, poplar, buckeye, chestnut, ash, magnolia, sweetgum, and hemlock are the dominant tree species in this forest type. In spring, a thick layer of herbaceous plants covers the ground. Many of these species have showy flowers, such as lady's slippers, trilliums, and violets. Flowering of this herbaceous layer is finished by the time the leaves come out on the upper-canopy deciduous trees (Sutton and Sutton, 1985). A third forest type, the cedar glades, is also restricted to northern Alabama. Scattered between the oak-hickory and mixed mesophytic communities are areas where extremely shallow soil covers limestone formations. The red cedar is the most common species and sometimes the only tree species found in these areas. In addition, many herbaceous species, including some endangered species, and various flowering shrubs are found in the cedar glades (Lineback and Traylor, 1973).

Fig. 3-6. Alabama vegetation types



Source: A.W. Kuchler, *The National Atlas of the United States of America* as cited in Lineback and Taylor, 1973.

The oak-hickory-pine forest community is the most common forest community in Alabama, extending from the oak-hickory and mixed mesophytic forests in the north through much of the central areas of the state. The dominant tree species in this mixed pine-hardwood community include bitternut, mockernut, and pignut hickories, white oak, post oak, northern and southern red oak, and loblolly and shortleaf pine. Fire and other disturbances play a large part in maintaining the oak-hickory-pine forest. Undisturbed forest areas contain primarily hardwood species, while pure stands of pine develop in disturbed areas. In the absence of further disturbances, the stands of pine are ultimately replaced by a more mixed forest in which single or small clusters of pines are found among the dominant hardwood species. Elevation and moisture levels also affect species distribution in the oak-hickory-pine forest. On dry ridges, Virginia pine and scarlet oak are the dominant species, while yellow poplar, shumard oak, willow oak, live oak, and bay magnolia commonly occur in wetter areas (Lineback and Traylor, 1973). Understory species include dogwood; viburnum; American beautyberry; and grasses, such as bluestem and panicum (Bailey, 1980).

In the extreme southern end of Alabama, the southern mixed forest is the principal vegetation community. This zone contains a mixture of broadleaf deciduous species, evergreens, and various pine species, including southern magnolia, cucumber tree, sweetgum, beech, yellow poplar, white oak, laurel oak, swamp chestnut oak, turkey oak, red bay, shortleaf pine, loblolly pine, longleaf pine, southern white pine, white hickory, and ironwood. Large areas in this community have predominantly pine forests, but these are in excessively dry or wet habitats, or in areas of second growth occurring after deforestation or fire. The climax vegetation type in this area is evergreen-oak and magnolia forest (Bailey, 1980). In sandy areas near the coast, the dense forest thins out. This vegetation subzone, called the pine-oak savanna, also contains a thick understory of shrubs (Lineback and Traylor, 1973).

Two other notable vegetation communities exist in Alabama—the Black Belt and the southern floodplain forest. The Black Belt is a narrow band approximately 20 miles wide that extends across south-central Alabama from the Montgomery area through Sumter County and into Mississippi. The belt coincides with an outcrop of limestone, known as the Selma Chalk, which weathers to a dark, heavy soil. In areas where this chalk soil is deep, the forest contains vegetation similar to the types found in adjacent regions as well as species found predominantly on limestone soils, including red cedar, overcup oak, shumard oak, chinquapin oak, durand oak, laurel oak, and nutmeg hickory. On thin or disturbed soils, the forest thins out and is replaced by open, prairie-like plant communities. The prairie species commonly found in the thin-soiled areas of the belt are prairie sunflower, prairie cornflower, prairie rose, Cherokee sedge, tuberous milkweed, Torrey's rush, cut-leaf verbena, and big bluestem grass (Lineback and Traylor, 1973).

The southern floodplain forest occurs along the middle and lower reaches of the Warrior, Tombigbee, Alabama, and Mobile Rivers. Although these rivers traverse other vegetation communities in the state, a distinct forest ecosystem parallels the rivers and is dominated by tupelo gum, bald cypress, pecan, and various oak species, including shumard

oak, overcup oak, water oak, willow oak, laurel oak, and swamp chestnut oak. Additionally, swamp privet, red bay, water elm, American elm, cabbage palm, sugarberry, and rattan vine are found in the floodplain forest (Lineback and Traylor, 1973).

Endangered and Threatened Plants

Twelve federally listed endangered or threatened plant species occur in Alabama's cotton-producing counties. Appendix B contains additional information about these species and their habitats.

Nontarget Species

The diversity of habitats within Alabama supports many different small mammals, birds, reptiles, and amphibians. Cotton fields are often noncontiguous plots of land with dispersed forested areas, or are adjacent to rivers, streams, and floodplains that support a diversity of terrestrial and aquatic life. A limited number of species have made suitable habitats within these often small (less than 30 acres) plots located near rural houses, while other species may occasionally enter the fields to forage or prey on insects. The following section describes the representative wildlife commonly found in agricultural areas in Alabama. Information for the following discussion and appendix A was compiled from several sources, including the Audubon Society Nature Guide (Sutton and Sutton, 1985) and other wildlife and endangered species books (Burt and Grossenheider, 1964; Conant, 1958; USDOI, 1980; Mount, 1986; USDA, 1975; Snedigar, 1962).

Terrestrial Vertebrates

Many small mammals, such as the whitetailed deer (*Odocoileus virginianus*), the raccoon (*Procyon lotor*), the opossum (*Didelphis marsupialis*), the red fox (*Vulpes fulva*), and the grey fox (*Uroeyon cinereoargenteus*) are often found in and around Alabama's farming areas. Deer and racoons have similar habitats and feed on fruits and acorns of naturally occurring plants, although they will browse among cotton plants if the area is overpopulated and food is scarce (Davis, 1979; Johnson, 1970). The swamp rabbit (*Sylvilagus aquaticus*), river otter (*Lutra canadensis*), and beaver (*Castor canadensis*) can be found near bodies of water and will sometimes venture into fields in search of food. Many different insectivorous bat, mouse, and shrew species are also present in the area.

Many insectivorous bird species are found in the cotton-producing areas, including the American crow (*Corvus brachyrhynchos*), the mourning dove (*Zenaida macroura*), the American robin (*Turdus migratorius*), the field sparrow (*Spizella pusilla*), and others. These areas also have a number of hawk and falcon species; several less well-known species inhabit or occasionally fly into the forests and wetlands adjacent to cotton fields. For example, numerous owl species, the yellow-throated and warbling vireo (*Vireo flavifrons* and *Vireo gilvus*), and brown thrasher (*Toxostoma* rufum) frequent these areas to feed on insects, fish, and small mammals.

The Alabama program area also has many reptiles, such as the brown snake (*Storeria dekayi*), Eastern box turtle (*Terrapene carolina*), the king snake (*Lampropeltis getulus*), and a number of snake, frog, and turtle species. Many of these are found in the riparian areas adjacent to cotton fields, but they may rove into the cotton fields to feed.

Domestic Animals

Livestock is an important component of the agricultural income in Alabama. Cattle, hog, chicken, and turkey farms are located throughout the state. Beef cattle, such as Aberdeen-Angus, Hereford, Shorthorn, and Santa Gertrudis; and Holstein-Friesian dairy cows are commonly raised on farms. White-Leghorn chickens and hybrids are raised for egg production, while the White Plymouth Rock chicken is a common broiler.

Dogs and cats are common farm pets throughout the program area. Rats are also found, often where large quantities of feed grains are stored on farms.

Aquatic Vertebrates

Fishes

The numerous natural and artificial water bodies and wetlands throughout the cotton-producing area contain diverse aquatic life. Several species of bass are present, as are various darter, minnow, cavefish, and shiner species. Other species present include the yellow perch (*Perca flavescens*), brook trout (*Salvelinus fontinalis*), and both the green (*Lepomis cyanellus*) and redbreast (*Lepomis auritus*) sunfish species.

Several catfish and bass species have become economically important in Alabama. Channel catfish (*Ictalurus punctatus*) and blue catfish (*Ictalurus furcatus*), as well as Florida strain large mouth bass, bluegill, shellcracker, and hybrid striped bass are raised in fish hatcheries. Game fish are stocked in public waters and private ponds throughout Alabama. Hatcheries in Eastaboga and Marion are the largest and produce approximately 130,000 catfish and 500,000 Florida bass annually (Turner and Cook, 1990).

Amphibians and Reptiles

Various newt, salamander, and turtle species inhabit the water bodies of the program area, such as the eastern newt (*Notophthalmus* spp.), the dusky gopher frog (*Rana areolata sevosa*), the northern cricket frog (*Acris crepitans crepitans*), the green salamander (*Aneides aeneus*), the Alabama red-bellied turtle (*Pseudemys alabamensis*), and the alligator snapping turtle (*Macroclemys temminicki*). Several species of aquatic snakes are also present in the area—the cottonmouth (*Agkistrodon* spp.) is the only indigenous poisonous snake.

Terrestrial Invertebrates

Numerous bugs, flies, crickets, ants, worms, grasshoppers, butterflies, and other invertebrates are found throughout the program area. Bees, butterflies, and other pollinators are widespread and crucial to the propagation of crops and other plant species. Honey bees (*Aphis mellifera*) are especially common and are important crop pollinators.

Cotton fields are also inhabited by a large number of species of insects, spiders, mites, and other arthropods referred to collectively as the cotton arthropod complex. (Information for the following discussion of these pests and beneficial species was compiled from the Cotton Scouting Handbook (Circular ANR-409), which is published through the Alabama Cooperative Extension Service.)

Tarnished Plant Bugs

The tarnished plant bug (*Lygus lineolaris*) overwinters as an adult and usually completes one or two generations on a number of hosts, including fleabanes, wild carrot, dock, mustard, and various legumes. The migration to cotton plants occurs primarily in June, and populations peak toward the end of June as the eggs begin to hatch. Although populations usually decline naturally during July, the number of pests does not necessarily indicate of how much damage will be incurred. Several other plant bugs may attack cotton and cause damage similar to that of the tarnished plant bug, including the clouded plant bug (*Neurocolpus nubilus*), the cotton fleahopper (*Pseudatomoscelis seriatus*), the rapid plant bug (*Adelphocoris rapidus*), and the four-lined plant bug (*Poecilocapsus lineatus*).

Cotton Bollworm and Tobacco Budworm

The cotton bollworm (*Heliothis zea*) and the tobacco budworm (*Heliothis virescens*) cause similar damage to cotton and are often found in the same fields; however, the tobacco budworm is more difficult to control. The tobacco budworm population peaks in June, while the late July generation is mostly bollworms.

Spider Mites

Spider mite (*Tetranychus urticae*) infestations arise near field margins, in weed clumps, around power poles, and so forth. The mites prosper in warm dry weather, and widespread infestation is usually the result of mechanical dispersion by farm equipment or windy weather because they crawl inefficiently and do not fly. Because they have a short life cycle (about 15 days), high populations may be reached quickly. However, mites are susceptible to predation and diseases, so they are usually controlled naturally.

Thrips

Tobacco thrips (*Frankiniella fusca*), flower thrips (*F. tritici*), and others tend to be chronic problems, migrating from various wild hosts in early spring as soon as cotton emerges. Heavy thrip damage is often associated with wet, cool spring weather, but the damage usually declines as temperatures become warmer and cotton grows more vigorously. Thrips may still be present but are no longer considered harmful, and are even considered beneficial by some because they serve as prey for several predators of the bollworm and budworm. The western flower thrip (*F. occidentalis*) was first identified in southeastern Alabama in 1980 and has since spread rapidly through the state; however, its status as a pest is poorly understood. Because a generation of thrips is completed in 2 weeks, each year multiple generations are present simultaneously in Alabama.

Cotton Aphid

Winged cotton aphids (*Aphis gossypii*) enter cotton in spring or early summer to give birth to live young. They have tremendous reproductive potential and can attain huge populations in a short time if unchecked. However, they are highly vulnerable to predation and parasitism. Aphids may cause severe damage to cotton seedlings in cool weather when

the reproduction and subsequent increase in natural enemies is retarded. Increases in insecticide use have also decreased populations of natural enemies and have allowed the cotton aphid to become a consistent pest in mid- and late-season cotton throughout most of Alabama.

Cutworms

The common cutworms in Alabama include the granulate (*Felitia subterranea*), variegated (*Peridroma saucia*), black (*Agrotis ipsilon*), and climbing cutworms. Cutworms come out of the soil to feed at night, doing most of their damage to cotton at the seedling stage. Damage is normally dispersed, occurring in low areas, on new ground, and in places where weed competition is heavy.

Beet Armyworm

The beet armyworm (*Spodoptera exigua*) deposits eggs on the bottom of leaves, in masses. When the larvae hatch, they feed in mass, skeletonizing the leaves near the egg mass (Alabama Cooperative Extension Service, 1991a). While the beet armyworm is mainly a foliage feeder, it has been known to feed almost exclusively on squares and blooms just before peak bloom. The beet armyworm is primarily a late-season cotton pest, but infestations along the coastal plain of Alabama have occurred as early as June and July. Since 1988 the beet armyworm has become a significant cotton pest in Alabama, increasing pest control costs up to $75 to $150 per acre in some areas (Smith, 1991b). Infestations are generally associated with dry weather. The most serious recent infestation occurred in 1988, when about 10% of the acreage in southeastern Alabama experienced 75 to 100% crop losses. Although the total acreage was not as extensive as in the 1988 season, the 1990 infestation was equally as severe. In 1989, heavy rains in June helped to control the beet armyworm. Control is difficult because early season applications of any insecticides that decimate or suppress beneficial insects can severely disrupt the natural predators of the beet armyworm, resulting in even worse infestations (Smith, 1991c; ACES, 1991b). Pigweeds are the preferred host of the beet armyworm (*Spodoptera exigua*), but populations may increase to damaging levels in cotton late in the season.

Other Pests

Cabbage loopers (*Trichoplusia ni*) seldom require chemical control because of the large number of natural controls, such as viral disease (evidenced by the black, slimy remains of larvae hanging from leaves). Populations of whiteflies (*Trialeurodes abutilonea*) peak late in the cotton season, and a generation requires 2 to 3 weeks to develop. The cotton leafworm (*Alabama agrillacea*) is a voracious leaf feeder and is usually found in largest numbers late in the season. This insect overwinters in the tropics and must migrate each year.

Beneficial Species

Approximately 600 different beneficial species of insects may be found in cotton, but only a few are found frequently. Beneficial species may be predators, feeding on a pest for a single meal, or parasites that make their home in the body of another insect from which they get food for at least one stage of their life. These beneficial species include green

lacewings (*Chrysopa* spp.); brown lacewings (*Hemerobius* spp.); minute pirate bugs (*Orius* spp.); big-eyed bugs (*Geocoris* spp.); damsel bugs (*Nabis* spp.); lady beetles (*Coccinella* and *Hippodamia* spp.); hover flies (*Syrphus* spp.); and certain predaceous thrips (*Thysanopterae*), mites (*Acarinae*), and spiders (*Araneidae*).

Aquatic Invertebrates

Diverse invertebrate aquatic organisms inhabit the water bodies within the program area. A variety of worms (*Oligochaeta*), leeches (*Hirudinea*), snails (*Gastropoda*), mussels (*Pelecypoda*), and shrimp (*Crustacea*) populate the inland waters of Alabama. These organisms feed on detritus, plants, and smaller invertebrates, such as copepods (*Calanoida* spp.), rotifers (*Keratell* spp.), and cladocerans (*Daphnia* spp.). These small invertebrates are near the bottom of the food chain, and thus directly or indirectly support all larger aquatic life. Many of these larger species are economically important to Alabama, such as shrimp harvested for commercial or research purposes and freshwater crayfish that are collected for human consumption.

The life cycle of several insects, such as the mayfly (*Ephemeroptera*), the dragonfly (*Odonata*), and the stonefly (*Plecoptera*) is closely linked to water. Aquatic larval and nymph forms are an important food source for many fresh water fish. A number of flies (for example, *Diptera*) and mosquitoes (*Culicidae*) are also dependent on water. Truly aquatic insect species that may be found in Alabama include giant waterbugs (*Belostomidae*), water scorpions (*Nepidae*), and water beetles (*Haliplidae*) (Klots, 1966; Borror and White, 1970).

Endangered, Threatened, and Proposed Vertebrates and Invertebrates

Thirty-four federally listed endangered, threatened, or proposed terrestrial and aquatic species occur in Alabama's cotton-producing counties. Appendix B describes each individual species and its habitat.

Water

Alabama relies heavily on more than 40,600 miles of rivers and streams for public and industrial water supplies, navigation, agriculture, industry, hydropower generation, and recreation. Other surface water resources in the state include 43 publicly owned lakes, reservoirs, and ponds covering approximately 504,336 acres; freshwater wetlands covering approximately 400,000 acres; and tidal wetlands covering 2,600,000 acres (Alabama Department of Environmental Management, 1990). Groundwater is used extensively in the state for public supply, as well as irrigation, livestock, and industrial-commercial supplies.

Surface Water

In 1985 approximately 96% of all water withdrawals in Alabama came from surface water supplies, with the remaining 4% coming from groundwater. Thermoelectric power generation accounted for 80% of the total withdrawals (Baker and Mooty, 1987). Approximately 45% of the population of Alabama relies on surface water for its municipal freshwater needs (USGS, 1986).

Lakes and reservoirs, created primarily by dams, are found throughout Alabama. Several of these lakes lie in areas of significant cotton production. Lake Eufaula, in Henry and Barbour Counties, is located in the south Alabama program area. In the central program area two reservoirs are located near cotton production: Miller's Ferry Reservoir, in Dallas and Wilcox Counties; and Lake Martin, in Elmore, Coosa, and Tallapoosa Counties. In north Alabama the

reservoirs created by damming the Tennessee River (Pickwick, Wheeler, Guntersville, and Wilson Lakes) are located in the cotton-producing counties of Lauderdale, Colbert, Limestone, Lawrence, Morgan, Madison, Jackson, Dekalb, and Marshall.

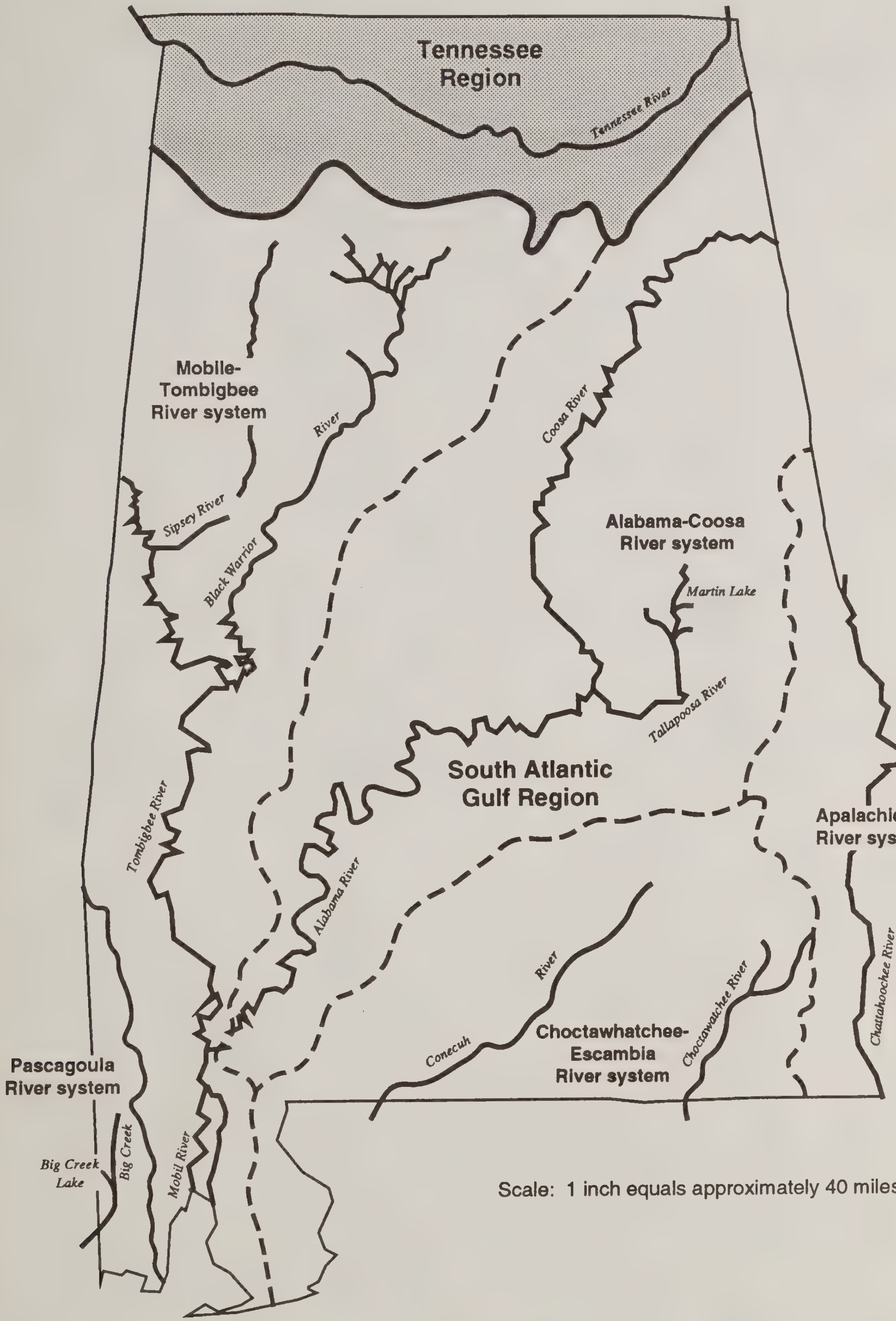
Alabama is physically situated in two water-resources regions: the Tennessee Region and the South Atlantic Gulf Region (fig. 3-7). The northernmost 7,500 square miles of the state are in the Tennessee Region and drain to the Tennessee River system, which eventually feeds into the Mississippi River (U.S. Army Corps of Engineers, 1981). The rest of the state, approximately 44,200 square miles, makes up the South Atlantic Gulf Region. This region drains to the Gulf of Mexico, either by way of the Mobile River system or the series of coastal rivers and tributaries. The South Atlantic Gulf Region is divided into five subregions within the state. These five subregions include the Alabama-Coosa River system, the Mobile-Tombigbee River system, the Choctawhatchee-Escambia River system, the Apalachicola River system, and the Pascagoula River system. The Apalachicola River system and the Pascagoula River system have relatively small parts of their drainage areas within Alabama. Cotton production in Alabama is most intense in the Tennessee Region and the Alabama-Coosa River system in the South Atlantic Gulf Region.

The Tennessee River enters Alabama at the northeastern corner of the state and flows southwest to Guntersville and then leaves the state at the northwest corner (fig. 3-8). Flows in the Tennessee River at the City of Florence, Alabama, averaged 34,850 cubic feet per second (cfs) in 1985 (USGS, 1987b). A series of reservoirs occupy most of the river stretch in Alabama. The largest of these are the Guntersville, Wheeler, Wilson, and Pickwick Reservoirs. The combined storage capacity of these dams is 454 billion gallons (USGS, 1986). Locks at the downstream limits of these reservoirs provide for navigation on the Tennessee River through Alabama and upstream to Tennessee and North Carolina (U.S. Army Corps of Engineers, 1981).

The Alabama-Coosa River system drains a total of 17,256 square miles of central Alabama (U.S. Army Corps of Engineers, 1981). The Alabama River is formed by the confluence of the Coosa and Tallapoosa Rivers, just north of the City of Montgomery. The Alabama River then flows southwest toward its confluence with the Tombigbee River, about 45 miles north of the City of Mobile; these two rivers form the Mobile River. Dams have been constructed in this river basin for power generation, flood control, and navigation. The Claiborne, Millers Ferry, and Jones Bluff Locks and Dams facilitate river traffic from the Mobile River upstream to Montgomery (U.S. Army Corps of Engineers, 1981). Several large dams and reservoirs are present throughout the river system. Flows in the Alabama River at the Claiborne Lock and Dam averaged 20,390 cubic feet per second (cfs) in 1985 (USGS, 1987b).

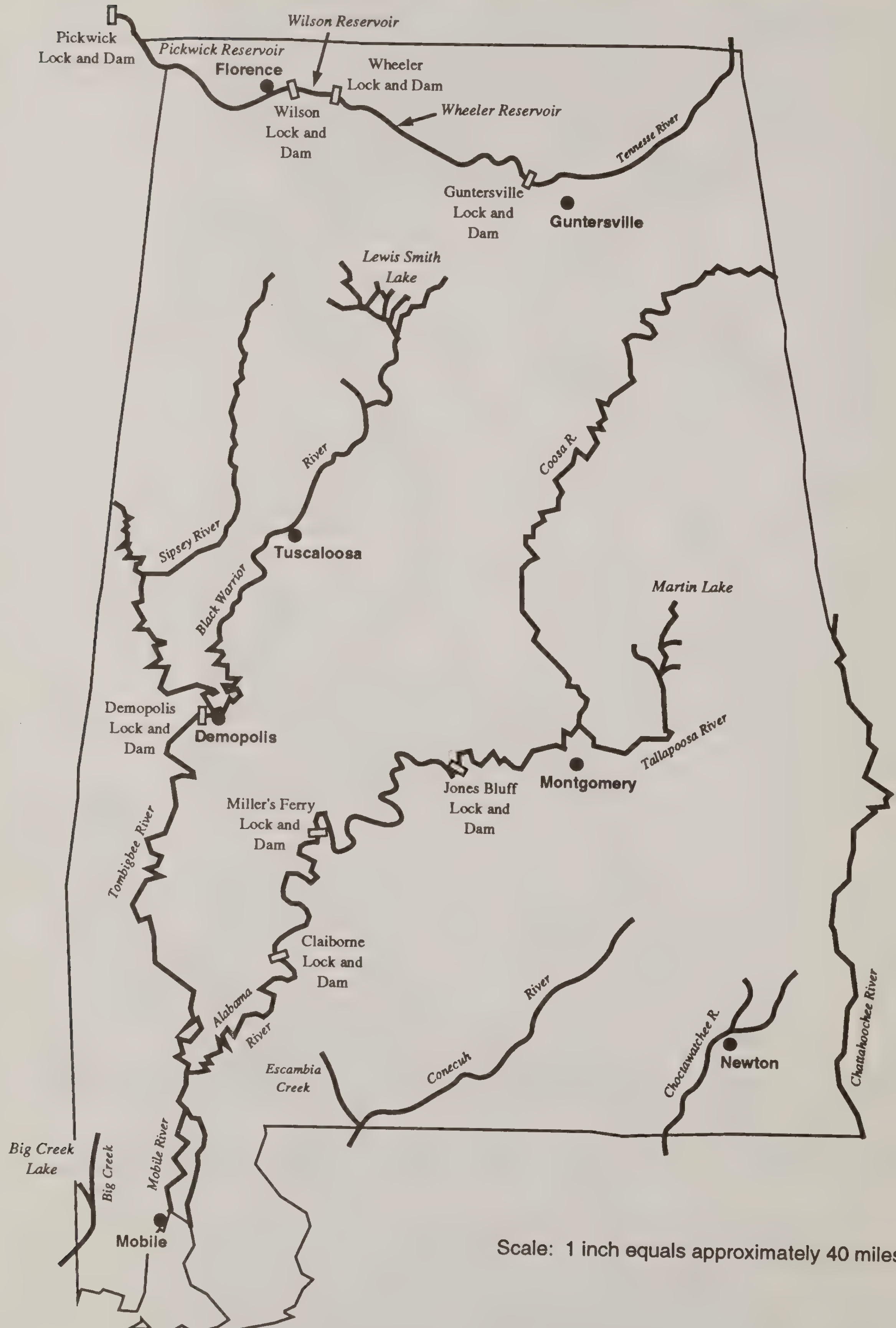
The Mobile-Tombigbee River system drains a large portion of central Alabama. The Tombigbee River rises in northeast Mississippi and enters Alabama near the center of the western state boundary. It is joined by the Black Warrior River near the City of Demopolis and flows south to join the Alabama River 45 miles above the City of Mobile. A series of locks and dams allows the industrial goods manufactured in the center of the state to be shipped southward to

Fig. 3-7. Water resources regions and subregions in Alabama



Source: National Water Summary, 1985—Surface-Water Resources, USGS, 1986.

Fig. 3-8. Surface water resource elements



Source: National Water Summary, 1985—Hydrologic Events and Surface-Water Resources, USGS, 1986.

Mobile. Flows in the Tombigbee River at the Demopolis Lock and Dam averaged 18,010 cfs in 1985 (USGS, 1987b).

The Choctawhatchee-Escambia River system comprises all the drainage that enters the Gulf of Mexico between the Mobile River and the Chattahoochee River. The two main rivers in this system are the Conecuh-Escambia River and the Choctawhatchee River. Flows in the Escambia River at the southern border of Alabama averaged 5,019 cfs in 1985 (USGS, 1987b). Flows in the Choctawhatchee River near Newton, Alabama, averaged 645 cfs in 1985 (USGS, 1987b).

Surface Water Quality

The surface water quality in Alabama is generally considered good throughout the state (ADEM, 1990). Dissolved solids concentrations in 1986 were typically less than 200 milligrams per liter (mg/L) except in streams in west-central Alabama, where concentrations occasionally exceeded 500 mg/L. The pH of the streams was near neutral, and the dissolved oxygen levels seldom fell below 4 mg/L (USGS, 1987b). The Alabama Department of Environmental Management (ADEM), by mandate of the Clean Water Act, assessed 12,016 miles of streams, 507,421 acres of lakes, 103 square miles of estuaries, and 50 miles of shoreline in a water quality assessment for calendar years 1988 and 1989. Approximately 90% of the assessed waters were found to fully support their designated uses (suitable for fishing and swimming under the Clean Water Act), although 16% of these waters exhibited possible degradation if corrective action were not taken. The remaining 10% were found to be either fully or partially unable to support designated uses. The primary cause of nonsupport was excessive levels of organic enrichment, which increases the biological oxygen demand and depletes available oxygen supply. The ADEM does not perform surface water pesticide sampling (according to a personal communication with McIndoe, 1990).

The quality of surface water in the state's reservoirs is of particular concern because reservoirs provide municipal water supply and recreation for local residents. Most of the state's large reservoirs are located in the Tennessee River, Alabama-Coosa River, and Mobile-Tombigbee River drainage systems; and the water quality problems in these reservoirs are similar. Water quality reflects a number of problems associated with municipal, industrial, agricultural, and natural sources (ADEM, 1990). High bacteria counts and low dissolved oxygen levels are common in many reservoirs as a result of nutrient enrichment from agricultural, municipal, and industrial activities. Aquatic weeds and polluted drainage from abandoned surface coal mines also pose threats to smaller reservoirs in the Tennessee River system and the upper areas of the Mobile-Tombigbee River basin. Reservoirs in the Alabama-Coosa River basin, excluding the Tallapoosa River drainage basin, are the most nutrient-enriched reservoirs in the state because of the fertile alkaline soils in the watershed. In the Tallapoosa River basin, however, soils are infertile and there are no large population centers. This is the only area of the state where cotton is not grown.

Groundwater

Groundwater withdrawals in the state averaged 290 million gallons per day in 1982 (USGS, 1985). This constituted 4% of the freshwater used in the state (Baker and Mooty, 1987). Approximately 55% of these withdrawals were used for public

supply, making up 52% of the public's water supply needs (USGS, 1985).

Groundwater aquifers in Alabama are divided into the coastal plain and the noncoastal plain aquifers (fig. 3-9). The principal aquifers of the coastal plain consist of the Citronelle-Miocene aquifer, the Floridian aquifer, the Tertiary sedimentary aquifer, and the Cretaceous aquifer system. The principal noncoastal plain aquifers consist of the Pennsylvanian Sandstone, Paleozoic Carbonate, and Igneous-Metamorphic aquifers. The coastal plain aquifers consist primarily of a sequence of unconsolidated sand beds and limestone and are found at depths of 75 to 200 feet. Yields range from 200 to 1,000 gallons per minute, with aquifers in the central portion of the state yielding as much as 1,400 gallons per minute (USGS, 1985). Most cities and towns on the coastal plain of Alabama depend solely on groundwater for domestic supplies. Some of the larger population centers, including Montgomery, Mobile, and Tuscaloosa must supplement supplies with surface water (USGS, 1985). Big Creek Lake, a 3,600-acre artificial reservoir on Big Creek in the Pascagoula River system, provides another source of drinking water for the City of Mobile.

The noncoastal plain aquifers consist of consolidated sediments and carbonate, igneous, and metamorphic rocks (USGS, 1987a). Well depths range from 75 to 500 feet throughout the noncoastal area. The Pennsylvanian Sandstone and Igneous-Metamorphic aquifers have yields averaging 1 to 10 gallons per minute, while the Paleozoic carbonate aquifer system has yields averaging 100 to 500 gallons per minute (USGS, 1985).

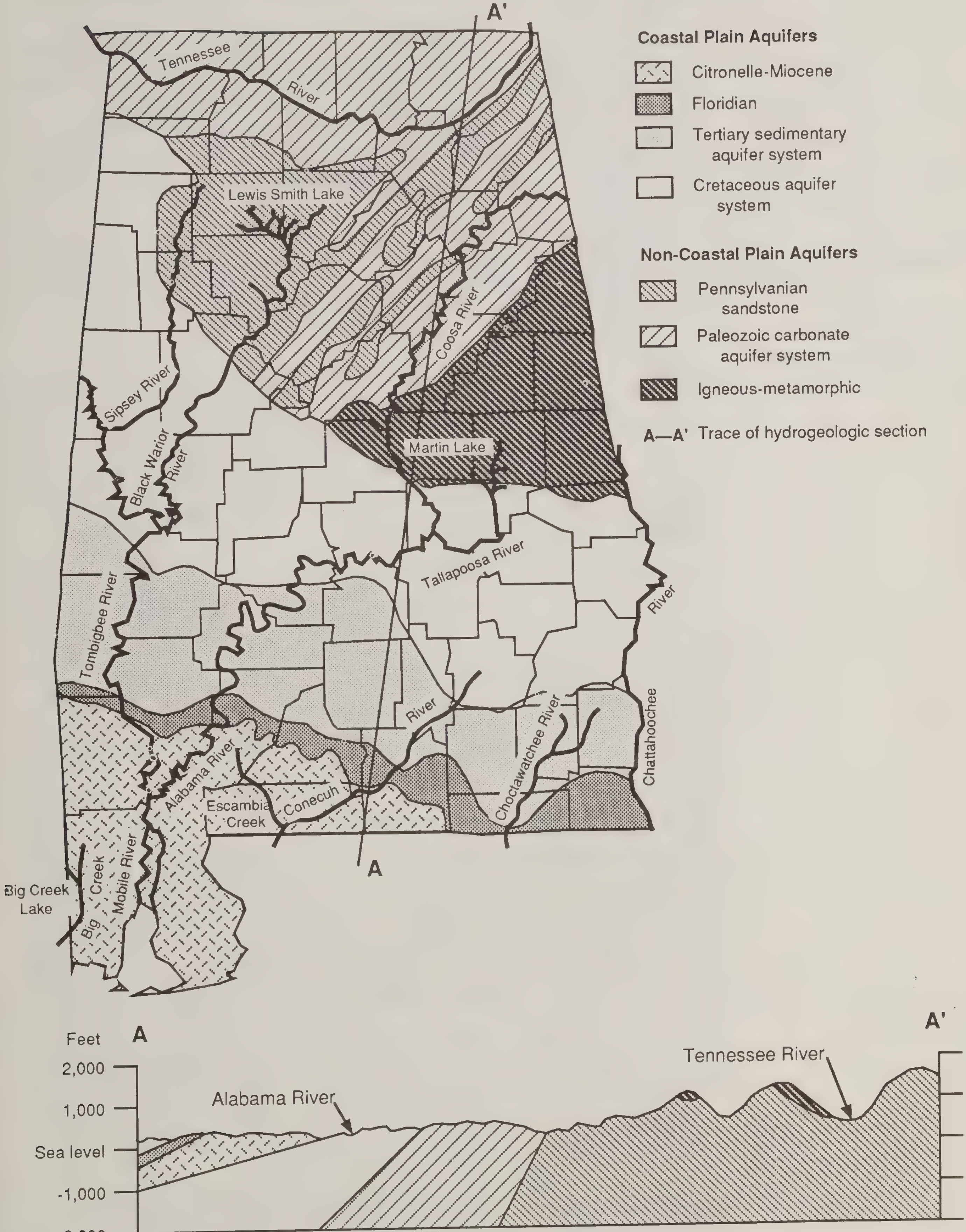
Over the past 20 years, Alabama has been experiencing declines in groundwater levels. Between 1973 and 1983, water levels in parts of southwestern Alabama have declined as much as 100 feet (USGS, 1984). Southwestern Alabama is most at risk from declining aquifer levels because of the small areal extent of the aquifers and because of the competition between municipal, industrial, and irrigation uses.

Groundwater Quality

The quality of groundwater in Alabama is generally good for most uses (ADEM, 1990). The complex geology within the state serves to protect many deeper aquifers from contamination. The freshest groundwater in the state, which contains less than 100 mg/L of dissolved solids, occurs in the recharge areas of all main aquifers.

Groundwater from coastal plain aquifers is typically good because water is pumped from the shallowest aquifers, which are usually near the recharge zone and are least likely to be contaminated. However, unconfined alluvial and coastal plain aquifers, like those on the coastal plain of Alabama, tend to be susceptible to contamination in areas of high population. Population centers provide a large number of point and nonpoint pollutant sources and more avenues for contamination (ADEM, 1990). Leaching of minerals from surface mining spoils, leaking underground storage tanks, surface impoundments, and landfills has caused localized contamination. Excessive pumping in coastal population centers has caused increased groundwater mineralization (USGS, 1987a). Salt intrusion in coastal wells has also

Fig. 3-9. Principal aquifers in Alabama



Source: National Water Summary 1986—Hydrologic Events and Ground-water Quality, USGS,1987

become a problem as salinity levels in groundwater continue to rise (USGS, 1984).

The noncoastal plain aquifers were found to have acceptable levels of dissolved solids (USGS, 1987a). Groundwater problems associated with the noncoastal aquifers in Alabama include high iron levels and corrosive pHs. For most domestic purposes, water hardness above 100 mg/L is not objectionable; hardness levels in the non-Coastal Plain aquifers are consistently measured below this level (USGS, 1987a). ADEM has begun a groundwater pesticide monitoring program in selected wells in row crop areas.

Human Populations

The total population of Alabama increased from 3.4 million to 4.1 million between 1970 and 1988. This represents a 19% growth rate, slightly less than the 21% increase in total U.S. population and substantially less than the 35% increase in the southern U.S. population during that time (USDC, 1990).

Rural residents account for between 10 and 100% of the total population in Alabama counties; 8 of the state's 67 counties (12%) are entirely rural (ADECA, 1989) (fig. 3-10). Most of Alabama's residents (60%) are located in urban areas; the proportion of rural residents has declined from 45% in 1960 to 40% in 1980 (ADECA, 1989). The trend toward urbanization began in the late 19th century when industrial development attracted farm workers to urban areas (Lineback and Traylor, 1973).

Alabama is not as densely populated as most of the states in the southern region of the United States. In 1988, Alabama had an average of 81 people per square mile, compared to an average of 97 people per square mile in the southern United States (USDC, 1990). The population density within Alabama counties in 1980 ranged from 16 people per square mile in Washington County to 600 per square mile in Jefferson County. Most of the rural counties had between 16 and 19 residents per square mile; the most densely populated averaged 34 per square mile (ADECA, 1989).

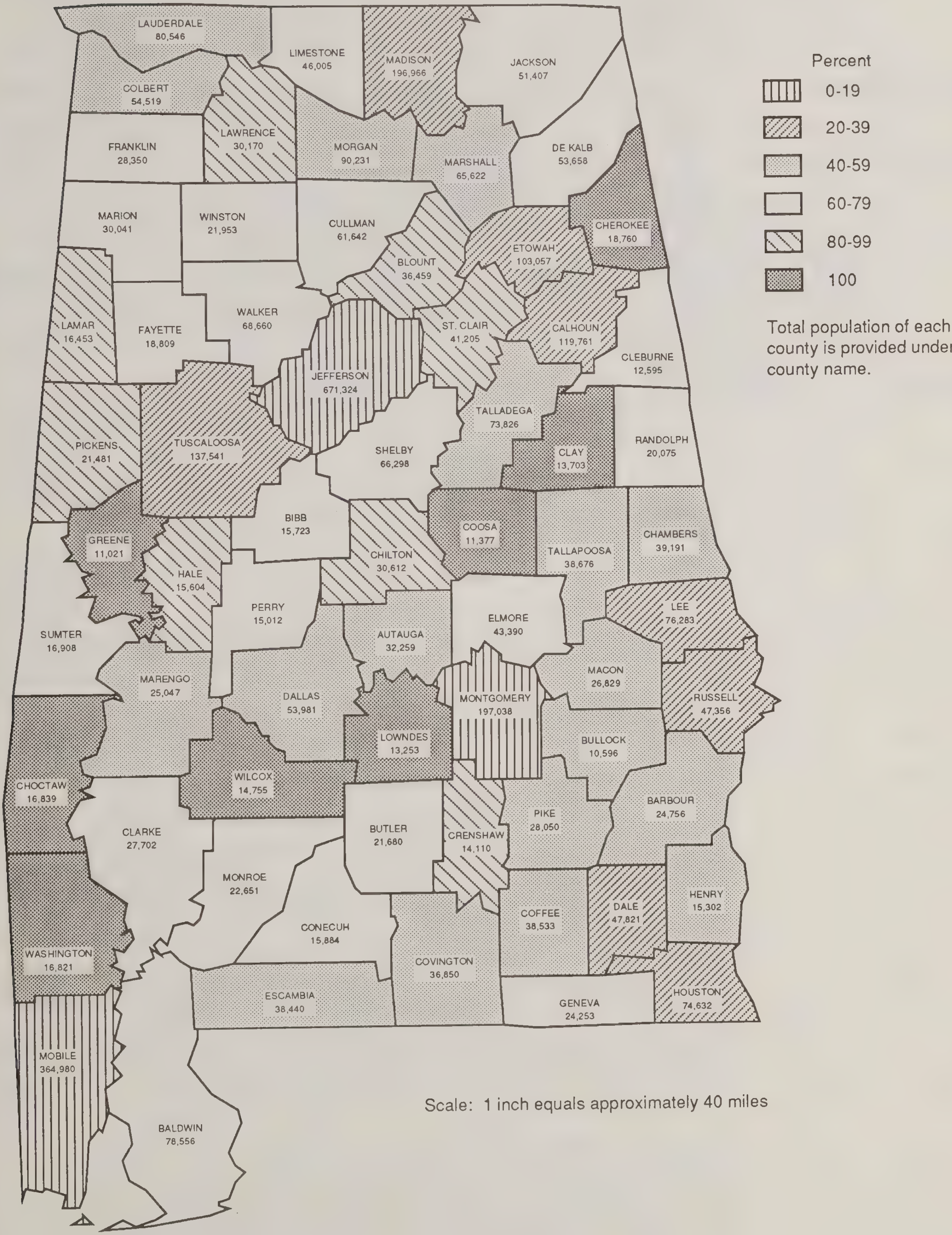
Population centers in north Alabama include Huntsville, in Madison County; Florence, in Lauderdale County; and Decatur, in Morgan County. Each of these cities is located in significant cotton-producing counties. Alabama's largest city, Birmingham, is not located in a cotton-producing county; however, Shelby County, a rapidly growing county adjacent to the city of Birmingham, does have some acres devoted to cotton production. In central Alabama, the cities of Selma and Montgomery are located in or adjacent to counties with significant cotton production. The southern Alabama cities of Mobile and Dothan are located in areas of less significant cotton production.

Special Groups

Individuals vary in their susceptibility to toxic substances in the environment. These variations in susceptibility can be the result of diet, age, heredity, preexisting physical conditions, and lifestyle (Calabrese, 1978). The Alabama population has not been statistically characterized for these factors. However, the young and the elderly are generally more sensitive than other groups.

In 1988 in Alabama, 39.7% of the population was in a sensitive age group: 1,115,000 residents 17 years old or less (27.2%) and 513,000 individuals 65 years or older (12.5%) (USDC, 1990). No information is available about the portion of these young and elderly populations that may be

Fig. 3-10. Distribution of 1980 rural population in Alabama



Source: ADECA, 1989.

located close enough to a boll weevil control operation to have any potential exposure to the insecticides. However, one-third of the 1988 U.S. farm population was in a sensitive age group: 20.2% of the population was under 15 years old and 14.1% was 65 years or older (USDC, 1990).

Background Health Risks

In 1986 in Alabama, a total of 931.3 deaths from all causes occurred per 100,000 population (USDC, 1990). Of these, 393.6 were attributed to cerebrovascular and cardiovascular disease, 201.9 to cancer, 33.2 to chronic respiratory disease, and 54.2 to accidents. These rates are slightly higher than the U.S. average of 873.2 deaths per 100,000 population from all causes, including 379.6 from cerebrovascular and cardiovascular diseases, 194.7 from cancer, 31.8 from chronic respiratory diseases, and 39.5 from accidents. Injuries are the main cause of death among young adults and children nationwide (NRC, 1985). Nationwide, the chance of developing some form of cancer during one's lifetime is about one in four (Calabrese and Dorsey, 1984; NRC, 1987).

Economics

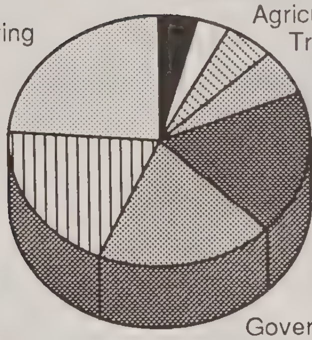
All sectors of the economy are important to Alabama's growth and stability. Manufacturing, wholesale and retail trade, government, and services contribute the greatest amount to income and employment, but the smaller industries, such as construction and mining, are also significant (fig. 3-11). Farm income represented 2% of the total value of goods and services produced in Alabama in 1986, as compared to manufacturing, which provided 24% of the total value (fig. 3-12). Alabama is less dependent now on farming as a source of income than it has been in the past (Holmes, 1988).

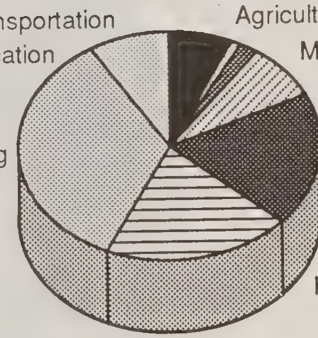
Per capita earnings from farming statewide were \$185 in 1986 and ranged from \$1,131 per person in Cullman County to \$1 per person in Escambia County. These statewide earnings are slightly greater than the national average of \$182 in per capita earnings from farming in 1986 (Holmes, 1988). Total Alabama per capita income in 1986 was \$11,357, lower than the average U.S. per capita income of \$14,597. Per capita earnings from farming accounted for 1.6% of 1986 per capita personal income in the state. However, this understates the overall economic impact of farming on the state because much of the manufacturing in Alabama uses farm-produced raw materials, such as broiler chickens and cotton. In addition, many merchants depend on selling farm inputs, such as chemicals, for a significant part of their earnings (Holmes, 1988).

Income in rural Alabama is lower than in metropolitan areas. In 1988 per capita income in Alabama's metropolitan areas ranged from \$11,679 to \$16,330. In contrast, per capita income in the eight rural counties (fig. 3-10) was lower than the state average of \$12,846 for all metropolitan areas and ranged from \$8,531 in Greene County to \$11,327 in Clay County (State of Alabama Department of Industrial Relations, 1990).

Alabama's rural areas are also characterized by greater unemployment than the rest of the state. Nine of the ten counties with the highest unemployment rates were primarily rural (table 3-1). Approximately 7% of Alabama's labor force was unemployed in 1989. This was higher than the U.S. average of 5.3% (State of Alabama Department of Industrial Relations, 1990).

Fig. 3-11. Alabama labor force and payroll, by industry



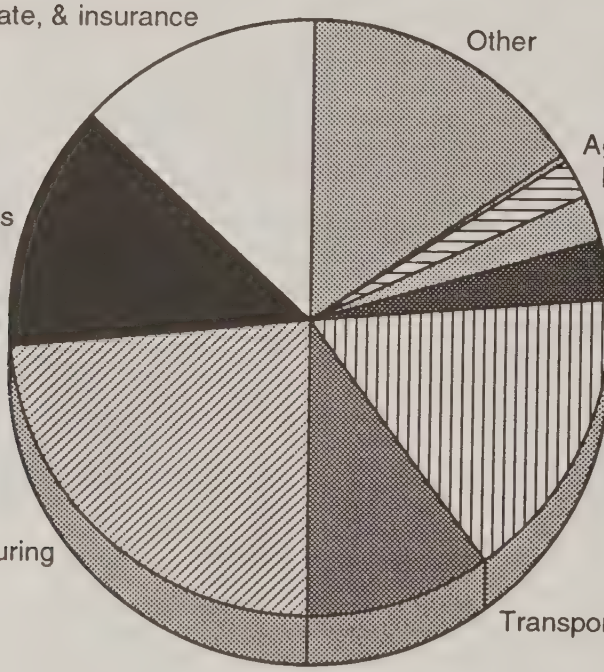


Civilian labor force in 1988 by industry	Number of Employees	Percent of totals
Manufacturing	401,000	23.6
Retail & wholesale trade	332,000	19.6
Government	325,000	19.2
Services	316,000	18.6
Construction	101,000	6.0
Transportation & communication	90,000	5.3
Agriculture	59,000	3.5
Finance, real estate & insurance	72,000	4.2
Total	1,696,000	100

Payroll, by industry ,1986	$1,000	Percent of total
Manufacturing	6,647,865	34.4
Retail & wholesale trade	3,893,084	20.1
Services	3,662,548	19.0
Construction	1,519,383	7.9
Mining	383,846	2.0
Transportation	1,659,429	8.6
Agriculture	59,631	0.3
Finance, real estate & insurance	1,332,084	6.9
Non-classifiable	148,344	0.8
Total	$19,306,214	100

Source: Information Publications, 1990.

Fig. 3-12. Value of goods and services produced in Alabama, 1986



Industry	$ Millions	Percent of total
Manufacturing	12,918	23.5
Services	7,397	13.4
Finance, real estate, & insurance	7,240	13.2
Transportation & public utilities	5,569	10.1
Retail & wholesale trade	8,855	16.1
Construction	1,754	3.2
Mining	1,389	2.5
Farms	1,134	2.1
Agriculture services, forestry, & fisheries	197	0.4
Other	8,554	15.5
Total	$55,007	100

Source: Information Publications, 1990.

Table 3-1. Alabama counties with the highest unemployment, and their rural population

Rank	County	Percent unemployed, 1989	Percent rural, 1980[a]
1	Wilcox	14.6	100
2	Butler	13.5	64
3	Bullock	12.7	58
4	Dallas	12.0	41
5	Greene	12.0	100
6	Marion	11.8	71
7	Lowndes	11.7	100
8	Washington	11.6	100
9	Lawrence	11.5	89
10	Jackson	11.5	61
	State of Alabama	7.0	40

[a]Data unavailable from 1990 census.

Sources: State of Alabama Department of Industrial Relations, 1990, and ADECA, 1989.

Agriculture

Livestock, including broilers, cattle, hogs and dairy products, and crops are important to the agricultural economy of Alabama. The state is the third largest producer of broilers and catfish in the United States, with 13.4 and 8.2% of the total U.S. production, respectively (ADAI, 1988). Livestock and poultry products accounted for $1,695 million, or 68% of the total agricultural receipts in 1988 (table 3-2). Crops such as peanuts, cotton, soybeans, and vegetables made up the remaining 32% of cash receipts, totaling $786 million.

Cotton

Cotton is the sixth most important commodity in Alabama in terms of revenue. Cash receipts for cotton lint and seed totaled $120 million in 1988 and represented 15% of total crop receipts and 5% of all farm commodity receipts. Alabama is the eighth largest producer of cotton in the United States (ADAI, 1990). In 1988, 375,000 acres of cotton were harvested and 380,000 bales of cotton were produced in the state. Six northern counties—Limestone, Madison, Lawrence, Colbert, Lauderdale, and Cherokee—were responsible for 50% of the state's 1988 cotton production (fig. 3-13). The yield per harvested acre for all counties averaged 486 pounds, ranging from 154 pounds in Marshall County to 808 in Talladega County.

Table 3-2. Cash receipts from Alabama commodities (1988)

1988 Rank	Item	Cash receipts ($ millions)
1	Broilers	936.5
2	Cattle and calves	452.7
3	Greenhouse and nursery	162.7
4	Peanuts	157.3
5	Eggs	143.4
6	Cotton	120.0
7	Farm forest products	89.6
8	Soybeans	87.7
9	Dairy	73.8
10	Vegetables	60.0
11	Hogs	46.7
12	Wheat	25.5
13	Hay	23.3
14	Catfish	19.4
15	Corn	14.3
16	Fruits	13.0

Note: These 16 commodities accounted for 98% of the total cash receipts from all farm commodities in 1988.

Source: ADAI, 1990.

Culture

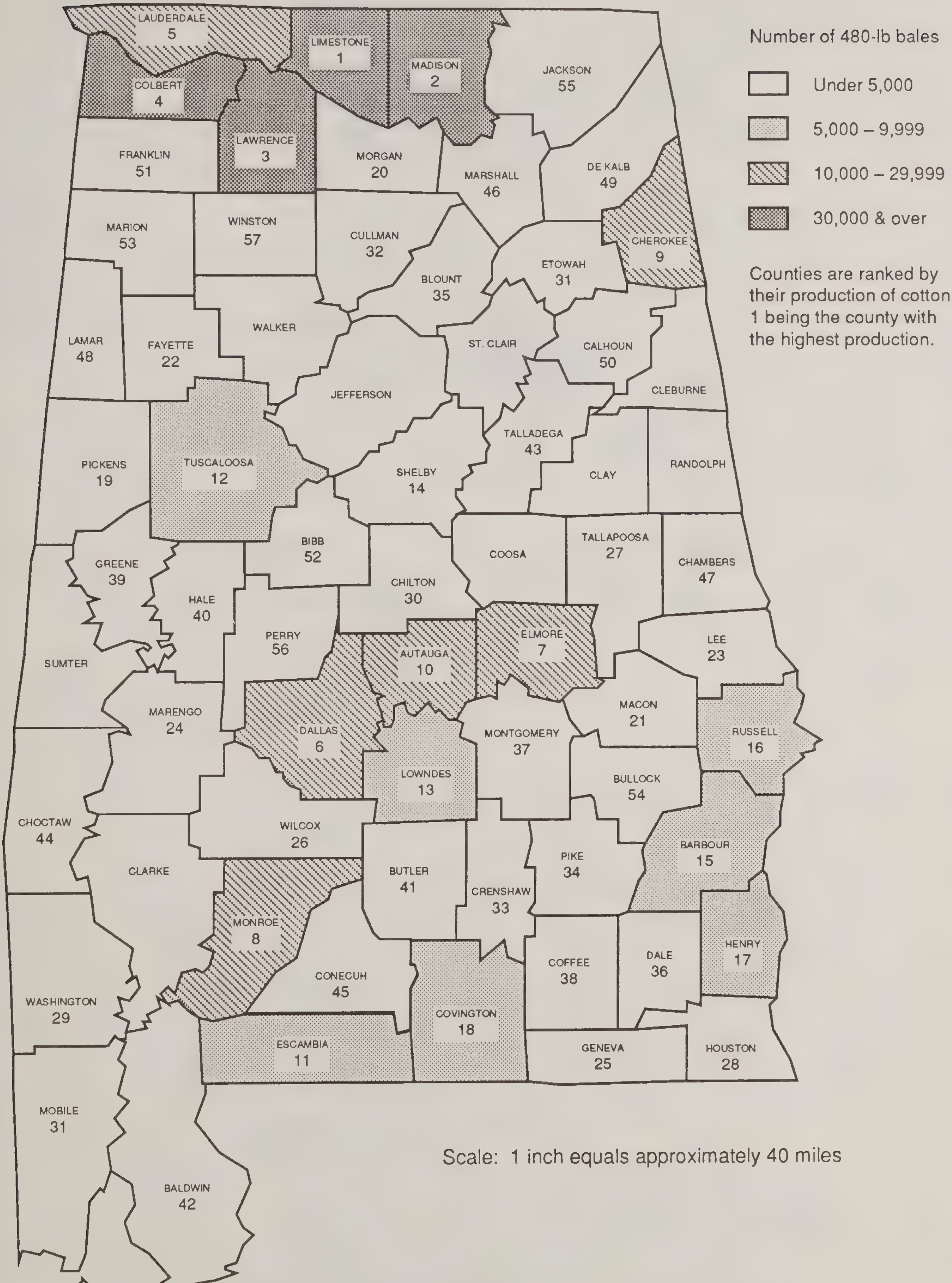
Many culturally significant sites are located throughout Alabama (fig. 3-14). Every county, except Choctaw, has sites listed on the National Register of Historic Places (USDI, 1976). Archaeological sites and monuments (such as the Moundville State Monument in Tuscaloosa County) provide information about the prehistoric and historic Indian cultures.

The importance of agriculture in the state's history is demonstrated by the many antebellum homes and plantations, such as Gainswood, a Greek revival mansion, and Bellingrath Gardens and Home (located in Marengo and Escambia Counties, respectively). Other areas, including forts, battlefields, cemeteries, museums, and monuments, preserve elements of Alabama's history during the 17th, 18th, and 19th centuries (ADECA, 1989; USDI, 1976).

Prehistoric

Evidence of human presence in Alabama during prehistoric times was discovered in Russell Cave near Bridgeport (Jackson County) in 1953. Broken utensils and charcoal remains of fires found in the cave were dated from between 6,500 and 7,000 B.C. Clovis points, a type of spear point used by Ice Age hunters to kill big game, were later found at the Quad site near Decatur, Alabama. Archaeologists have dated excavated materials in that area and believe Indian hunters came into the Tennessee Valley of Alabama as early as 10,000 B.C., in pursuit of big game, such as the prehistoric mastodons and woolly mammoths.

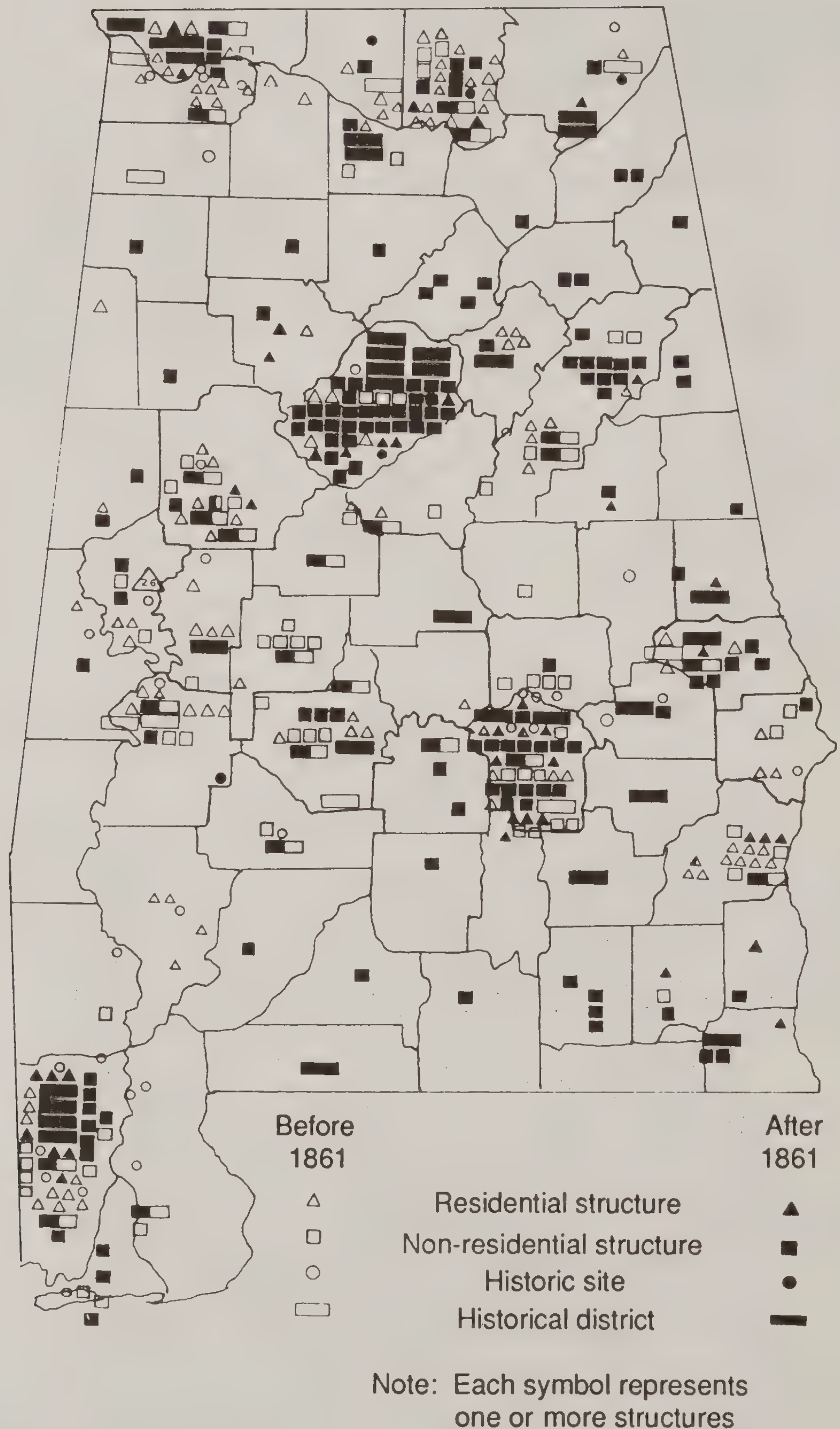
Fig. 3-13. Alabama cotton production, 1989



Cotton is produced in 55 of Alabama's 67 counties.

Source: ADAI, 1989.

Fig. 3-14. Alabama sites on the National Register of Historic Places



Source: ADECA, 1989.

Archaeological remains of prehistoric Indians in Alabama range from "rock towns" or cave shelters along the river bluffs to the earthen pyramids and fortified town sites of the semicivilized people known as the Mound Builders. Throughout the state, particularly in the large drainage basins, there are large habitation sites, shell refuse heaps, and terraced flat-top ceremonial mounds, which served as foundations for temples or houses. The Moundville State Monument is one of the most well-preserved mound groups in the country (Walker, 1975).

Historic

The Spanish are the earliest known European explorers of Alabama. Several expeditions searching for gold arrived during the 16th century, some arrived in Mobile Bay, and others (including Hernando de Soto's) traveled along inland routes from what is now Florida and Tennessee. The first permanent European settlements were established by the French in the early 18th century soon after France relinquished her claims in the Treaty of Paris (1763). The British acquired a small area in the southern part of the state in the treaty, and Spain continued to hold claim to other parts of the state. During the late 18th century and early 19th century, the United States gradually acquired the Mississippi territory (of which Alabama was part), from the Spanish and the Indians through invasions, civil wars, and treaties.

Historic tribes included the Choctaw, Chickasaw, Cherokee, Creek, and Alabama. By the mid-19th century the Indian culture had virtually disappeared from the state. Continuous conflicts and disease (such as smallpox and measles) reduced Indian populations. The U.S. acquisition of Indian lands and the eventual relocation of the Indians to Oklahoma left 160 Indians in the entire state in 1860.

Agriculture

The dominance of agriculture in Alabama derives from the availability of large areas of productive agricultural land after dispersion of the Indians. Also during the 19th century farm families from Georgia, North and South Carolina, Tennessee, and Virginia migrated to Alabama. (Some Europeans, including refugees from Ireland and Germany, settled in Alabama. However, 85 to 90% of the state's pre-Civil War white population were from the northern states or were descended from these original settlers.) Farming was becoming less profitable in these older states primarily because many rich soils were depleted after being continuously planted in cotton or tobacco and because the most productive areas in the states were owned by relatively few established families. Distribution (free or at low cost) of productive agricultural land (former Indian territory) by the federal government also provided an incentive to migrate to Alabama (Lineback and Traylor, 1973).

Cotton. In 1821 the beginning of steamboat service up the Alabama River to Montgomery made the seaport of Mobile easily accessible to Alabama cotton planters. Slave labor and the increasing number of cotton gins made cotton a mass production crop. The first cotton factory in the state was erected in Madison County in the early 1830s, and a cotton gin manufacturing plant was established in Montgomery County in 1833. As the port of Mobile opened the markets of the world to this commodity, cotton became the economic backbone of the state (Walker, 1975).

Alabama's economy revolved around cotton for most of the first 60 years of the 19th century. Other pre-Civil War industries included iron foundries, shoe factories, grist and lumber mills, and nitre (mineral used to make gunpowder) manufacturing. As a result of the reliance on cotton throughout the first half of the 19th century, the soil was badly depleted. After the Civil War a move toward industrialization occurred, centering around textile, iron, and steel production. Cotton was further deemphasized late in the 19th century by boll weevil crop destruction. Peanuts and potatoes then became alternate crops (Lineback and Traylor, 1973).

Visual Resources

Visual resources consist of the land, water, vegetation, animals, and other natural or manmade features visible in Alabama. Highways, rivers, and trails of the area pass through a variety of characteristic landscapes where natural attractions, such as forests and coastal marshes, can be seen and where cultural modifications exist. Vast acreages of cropland, pasture, and forest land provide scenic views.

Alabama's visual resources vary because of the state's topography and diverse land uses. The steep terrain prevailing in the Appalachian foothills limits the range of view but provides rugged mountain vistas. Occasional valleys and streams provide more open panoramas in this area of northern Alabama. The Tennessee River Valley is also characterized by hilly terrain, but it is broken up more frequently by flat to rolling areas. The southern part of Alabama (including the coastal marshlands and the Mobile River estuary) is fairly flat to rolling and, therefore, provides open scenic vistas. Different vegetation and wildlife are evident in riparian and coastal areas.

Most uses of land in the state—agriculture, forest land, and urban—also influence visual qualities. In agricultural areas, green fields planted with row crops, such as cotton, peanuts, soybeans, potatoes, and hay, are commonly seen. Some of these plants flower in the spring and provide additional color. The relatively flat topography typical of agricultural areas is broken by farm houses, barns, silos, fences, farm machinery, small aircraft (used for crop dusting), and livestock grazing in open fields. Additionally, the reddish-yellow to brownish-red soil enhances the vistas when fields are tilled during the spring and fall (Lineback and Traylor, 1973).

Many different trees and other vegetation may be seen in Alabama because forest land occupies approximately one-third of the state. Scattered horizons in the southern part of the state are dominated by coniferous loblolly pine forests, while various deciduous hardwood forests are common in northern parts of the state.

Air Quality

Under the Clean Air Act of 1977, as amended, Alabama is required to ensure that concentrations of designated pollutants do not exceed federally mandated air quality standards. This is done on the state level by preparing a State Implementation Plan (SIP), which outlines Alabama's program to meet the federal standards and, when the federal standards are exceeded, allows for plans to achieve attainment (Currie, 1989). EPA must approve the original SIP, as well as all modifications. When an area in the state does not meet the federal standards for a specific pollutant, it is referred to as a nonattainment area.

Air quality, for purposes of the Clean Air Act, is measured by comparing air pollutant levels with appropriate primary and secondary National Ambient Air Quality Standards (NAAQS) for each of six criteria air pollutants. (Primary standards apply directly to human health, while secondary standards consider the health of surrounding flora and fauna.) These six pollutants include total suspended particulates, sulfur dioxide, ozone, nitrogen dioxide, carbon monoxide, and lead (40 CFR 50 et seq.).

In 1989 air quality at all monitoring stations met the primary and secondary NAAQS for sulfur dioxide, carbon monoxide, and ozone (EPA, 1990). Air samples in two cities exceeded the maximum 24-hour standard for total suspended particulates during at least one-quarter of 1989: one station in Dothan (Houston County) and two stations in Birmingham (Jefferson County). Two stations in Leeds (Jefferson County) and one station in Troy (Pike County) collected air samples that exceeded the standard for lead concentrations during at least one-quarter of 1989 (EPA, 1990). All six nonattainment areas are in urban areas.

Noise

The sound environment in Alabama may be characterized by ambient noise levels and factors that influence these levels. In Alabama, as in other states, a dichotomy exists between urban and rural areas, with much lower average background noise levels found in the latter.

General farm activity, in the absence of any heavy machinery being operated, is approximately 50 to 80 decibels (dBs) (Plog, 1988). Periodic increases in dB levels may occur from the operation of agricultural equipment, such as trucks, tractors, harvesters, and aircraft used to apply pesticides.

Trees and shrubbery serve to dampen the noises typical of agricultural areas. The terrain also affects the ambient noise level, with sounds carrying farther over flat terrain than over hills and valleys.

Chapter 4

Environmental Consequences

Overview

This chapter discusses the potential environmental impacts of implementing the next increment of the National Boll Weevil Cooperative Control Program in central and northern Alabama. This chapter evaluates the possible consequences of implementing the next phase for each of the environmental resources described in chapter 3. Also presented are potential cumulative and synergistic environmental effects, unavoidable environmental effects, irreversible and irretrievable commitment of resources, short-term uses versus long-term productivity, conflicts with other agencies, and energy requirements and conservation potential. In some instances, the likely impacts would not differ from those for the 17-state beltwide program, as discussed in volume 1 of the Draft EIS. In those cases, the reader is referred to the appropriate section of volume 1 to avoid unnecessary repetition in this document.

Geology and Topography

Geology interacts directly and indirectly with all other environmental factors. For example, the rock type found in a specific area can influence soil development, composition of vegetation communities, and plant growth rates. Soil moisture retention is indirectly related to the geologic material and weathering conditions. The environmental resources most closely associated with geology are soil and water resources. Although the program may affect these related elements, it is not expected to have any direct impact on geology and topography.

Climate

The factors influencing climate are so large in scale compared to the size of implementing the next increment that it is not expected that there would be any impact, even briefly, on the climate in Alabama.

Soils

Volume 1 of the Draft EIS contains a complete discussion of the potential impact of malathion and diflubenzuron on soils. No additional impacts are expected from using these two chemicals in central or northern Alabama.

Additional information suggests that soils will not be adversely affected by the use of methyl parathion. For instance, in a study on loam and sandy soils, a normal application of methyl parathion (50 ppm) resulted in little impact to microflora and had a stimulatory effect on populations of fungi, actinomycetes (Naumann, 1971; as cited in Tu and Miles, 1976), and nitrifiers (Naumann, 1970; as cited in Tu and Miles, 1976).

Vegetation

Methyl parathion and diflubenzuron are generally nonphytotoxic when used at label rates (Thomson, 1989) and therefore are not expected to affect vegetation in fields adjacent to cotton. Damage from malathion has been reported on a variety of fruits, cucurbits, string beans, and some ornamentals, including ferns, hickory, viburnum, lantana, junipers, petunias, spirea, white pines, maples, and elms (Thomson, 1989). However, no information was available on the formulation of malathion that caused the damage or the extent of damage.

There is evidence that some formulations of methyl parathion are phytotoxic to cotton. Field studies conducted in 1972 and 1986, using methyl parathion 5 EC and methyl parathion 4 EC at application rates of 1.12 kg active ingredient (a.i.)/ha (1 lb a.i./acre), resulted in adverse effects on cotton growth, reproductive development, and yield (Youngman et al., 1990). However, the formulation proposed for use in the national program is not the same as those tested; the application rate in the program would be one-half of that used in the field studies.

The reproduction of vegetation adjacent to cotton fields that were treated with malathion and methyl parathion may be adversely affected for a short period because of the reduction of insect pollinators. No long-term impacts to vegetation are anticipated because of the short duration of the program and the short persistence of the insecticides on plants.

Federally Listed Endangered, Threatened, and Proposed Plant Species

Twelve plant species that occur in Alabama are listed by the Fish and Wildlife Service as endangered or threatened, or are proposed for listing. These species were evaluated in terms of the potential for the program to affect their continued existence. Appendix B describes the biology of each species, the risk assessment process used to determine whether they are likely to be affected, the conclusions of the assessment, and the protection measures developed to ensure that none of the "may affect" species is jeopardized by the Alabama program.

Program "No Effect" Plant Species

It was determined that the following seven plant species would not be affected by the proposed boll weevil control program in Alabama:

- American hart's-tongue fern
- Alabama canebrake pitcher-plant
- Green pitcher-plant
- Lyrate bladder-pod
- Price's potato-bean
- Leafy prairie-clover
- Little amphianthus

Program "May Affect" Plant Species

It was determined that the following five plant species would possibly be affected by the proposed boll weevil control program in Alabama (measures described in appendix B were developed to protect these species):

- Alabama leather flower
- Harperella (Piedmont Bishop's weed)
- Mohr's Barbara's buttons
- Kral's water-plantain
- Relict trillium

Nontarget Terrestrial Wildlife and Aquatic Species

Wildlife and aquatic species may be affected if they are exposed to the program pesticides, or they may be temporarily disturbed by the application equipment during the next phase of the program in central and northern Alabama. Only individual animals are likely to be affected; no major population of wildlife or aquatic species is likely to be seriously affected, and no other aspects of the program are likely to affect them. The potential impacts on

endangered and threatened species of wildlife and aquatic species are discussed later in this section.

Wildlife and Aquatic Species Risk Assessment

The possibility that any terrestrial or aquatic organism might be affected by the control program insecticides is a function of the toxicity of the chemical to that type of organism and the level of exposure that organism is likely to experience during the program. To evaluate that possibility, a risk assessment was conducted that combined information on the toxicity of the program chemicals with estimated exposures that various Alabama species might experience. The risk assessment for Alabama species adapted the methodology used for assessing program-wide risks as described in appendix B of volume 1 of the Draft EIS. The risk assessment compared toxicity levels found in laboratory studies with estimated exposures of representative Alabama wildlife and aquatic species that are common inhabitants of the state.

Wildlife Risk Estimates

The representative Alabama wildlife species used in the risk assessment included birds, mammals, reptiles, amphibians, and domestic animals with a range of body sizes and diets for which these biological parameters were generally available. Some common terrestrial invertebrates were also included. These species were assumed to receive insecticide doses through three exposure routes simultaneously: by breathing in insecticide droplets immediately after spraying, by absorbing insecticide through the skin, and by consuming food and water contaminated with insecticide.

Typical and extreme doses of each control chemical were estimated for each wildlife species based on insecticide from drift or direct spray exposures. These estimated doses were then compared with the acute toxic dose level that EPA (1986) suggests as a risk criterion for terrestrial species—that is, 1/5 of the LD_{50} (toxic dose lethal to one-half of a test group of animals) of the most closely related tested species. For example, estimated doses of malathion to the red fox were compared to the laboratory-determined LD_{50} of the domestic dog. Because so little toxicity data are available for reptiles and terrestrial stages of amphibians, bird data were used as a surrogate. For nonendangered wildlife species, EPA assesses the risk from pesticide exposure according to the following scale:

Slight—expected dose $<1/5\ LD_{50}$
Moderate—$1/5\ LD_{50} \leq$ expected dose $< LD_{50}$
Significant—expected dose $\geq LD_{50}$

Doses below the 1/5 LD_{50} level (slight) are assumed to present a low or negligible risk, doses between the 1/5 LD_{50} level and the LD_{50} (moderate) are assumed to present a risk that may be decreased by the restricted use of pesticide, and doses above the LD_{50} (significant) are assumed to present an unacceptable risk. Appendix A presents the details and results of the Alabama wildlife and aquatic species risk assessment.

Aquatic Species Risk Estimates

The aquatic species portion of the risk assessment compared the expected environmental concentrations (EECs) of program insecticides from drift or runoff into ponds, streams, and rivers to LC_{50}s (concentrations lethal to one-half of a test

group) from laboratory tests on similar species. The following risk categories from EPA (1986) were used to assess the control program's effect on aquatic species in Alabama:

Slight—EEC $<1/10$ LC_{50}
Moderate—$1/10$ LC_{50} $\leq$EEC $<1/2$ LC_{50}
Significant—EEC $\geq 1/2$ LC_{50}

The American oyster was used as a toxicity surrogate for the effects of malathion on freshwater mussel species in Alabama. For the effects of diflubenzuron and methyl parathion on freshwater clams, fish were used as toxicity surrogates because evidence suggests that known fish toxicants are comparatively less toxic to freshwater mussels during acute exposure (Havlik and Marking, 1987). For aquatic reptiles, the tadpole of the western chorus frog was used as the toxicity surrogate for malathion and methyl parathion, and the channel catfish was used for diflubenzuron.

Risk Assessment Conclusions

The wildlife portion of the risk assessment reached the following conclusions:

1. Malathion would generally be safe with respect to terrestrial species, except for insects such as the honey bee.

2. Diflubenzuron would be safe for terrestrial wildlife and is not likely to affect honey bees.

3. Methyl parathion would be safe under normal exposures but would affect animals that received significant exposures from being directly sprayed and from feeding exclusively on insecticide-contaminated food.

The aquatic species portion of the risk assessment concluded the following:

1. Malathion would likely affect species such as bluegills or painted turtles found in farm ponds and could also affect fish species such as walleyes and invertebrates such as *Daphnia magna* if the ponds or streams were contaminated from insecticide drift (without a buffer) or runoff.

2. Diflubenzuron is not likely to affect any aquatic species in Alabama.

3. Methyl parathion should not adversely affect any of the fish, clams, aquatic reptiles, or amphibians in Alabama. However, some species of aquatic invertebrates, such as *Daphnia magna* or crayfish, may be at risk from methyl parathion.

Federally Listed Endangered, Threatened, and Proposed Wildlife and Aquatic Species

Thirty-four wildlife and aquatic species in Alabama are listed by the Fish and Wildlife Service as endangered or threatened or are proposed for listing. These species were evaluated in terms of the potential for the program to affect their continued existence. Appendix B describes the biology of each species, the risk assessment process used to determine whether they are likely to be affected, the conclusions of the assessment, and the protection measures developed to ensure that none of the "may affect" species is jeopardized by the Alabama program.

Program "No Effect" Species

It was determined that the following five wildlife and aquatic species would not be affected by the proposed boll weevil control program in Alabama:

- Alabama beach mouse
- Perdido Key beach mouse
- Red Hills salamander
- Pygmy sculpin
- Watercress darter

Program "May Affect" Species

It was determined that the following 29 wildlife species may be affected by the proposed boll weevil control program in Alabama (protection measures described in appendix B were developed to ensure no jeopardy):

- Gray bat
- Indiana bat
- Piping plover
- Bald eagle
- Red-cockaded woodpecker
- Gopher tortoise
- Alabama red-bellied turtle
- Flattened musk turtle
- Eastern indigo snake
- Cahaba shiner
- Alabama cavefish
- Boulder darter
- Slackwater darter
- Snail darter
- Gulf sturgeon
- Tulotoma snail
- Inflated heelsplitter mussel
- Judge Tait's mussel
- Marshall's mussel
- Penitent mussel
- Alabama lamp pearly mussel
- Fine-rayed pigtoe
- Orange-footed pearly mussel
- Pale lilliput pearly mussel
- Pink mucket pearly mussel
- Rough pigtoe
- Shiny pigtoe
- Stirrup shell
- Alabama cave shrimp

Cotton Insect Pests

The proposed implementation of the next increment of the National Boll Weevil Cooperative Control Program could have short-term adverse impacts and long-term beneficial impacts on other cotton insect pests.

As discussed in volume 1 of the Draft EIS, in the absence of chemical treatments, cotton insect pests are often kept below economically damaging levels by predators and parasites. These beneficial predators and parasites are in dynamic equilibrium with their pest prey or hosts. When the pest population increases, the populations of beneficial insects increase as well (Ables et al., 1978). While some annual environmental conditions may favor the growth of some pest species, biological controls can reassert their

controlling influence, and pest populations can stabilize again over time.

Boll weevils have no predators, parasites, or naturally occurring diseases that provide an economically acceptable level of control; therefore, insecticides are the only method now available to control large populations of boll weevils in the warm, humid climate of Alabama. When broad-spectrum or nonselective chemicals are applied to control boll weevils, the toxic effects of the chemical may reduce or eliminate the nontarget pests as well as the beneficial insect populations that normally control them. However, if the nontarget pest is unaffected by the chemical treatment, elimination of the beneficial insects may allow the non-target pest population to grow to levels that would cause damage.

Malathion and methyl parathion are toxic to beneficial insects, and they are not effective in controlling some secondary pests in Alabama, including tobacco budworms, bollworms, beet armyworms, and aphids. Thus, repeated applications of these chemicals may cause elimination of the beneficial insects and contribute to the population growth of these secondary pest species. In addition, the repeated long-term application of broad-spectrum insecticides may contribute to the development of chemical resistance in target and nontarget species. Several of the nontarget cotton pests in Alabama have already developed some level of resistance to many insecticides. When resistance occurs, beneficial insects may be the only control method available to limit the size of the pest population. Eliminating the beneficial insects in this instance could result in uncontrollable outbreaks of the pest (Knipling, 1979).

The next increment of the program may have the short-term effect of contributing to local outbreaks of aphids, bollworms, and tobacco budworms in the 2 to 3 years when early-season treatments are required for more than two consecutive times. However, in the long term, with the boll weevil eradicated as an economic pest, there would be a significant decrease in the need for insecticide applications early in the season. This would allow for the use of a true integrated pest management system in Alabama for the remaining cotton pest species. For example, with boll weevils eradicated, budworms and bollworms could be managed using control measures such as *Bacillus thuringiensis* and beneficial insects. Also, aphids could be managed with natural predators, parasitoids, and naturally occurring fungal diseases, plant bugs with one insecticide treatment, and seedling thrips with systemic aldicarb (according to a personal communication with Smith, 1990).

Water Quality

The initiation of a control program will not change the water requirements of cotton production and will, thus, result in negligible effects on surface water and groundwater quantity. However, there may be short-term effects on water quality because of the possibility of insecticides entering the aquatic environment. Any short-term effects would be comparable to those that might occur when individual producers, outside the program, attempt to control boll weevil populations.

When released into the environment, chemical insecticides may enter aquatic systems through three main pathways:

1. Drift from pesticide application equipment may land on neighboring streams and ponds.

2. Runoff from fields may contain insecticide concentrations that enter streams and rivers.

3. Pesticides may leach into the ground with infiltrating precipitation and enter groundwater resources.

Mathematical models predicted the concentration of insecticides entering the aquatic environment through these methods. This analysis required three models: AGDISP (Agricultural Dispersal Model), GLEAMS (Groundwater Loading Effects of Agricultural Management Systems), and EXAMS II (Exposure Analysis Modeling System). A discussion of these models and the assumptions and methodologies used is provided in appendix A.

Surface Water Quality

Surface water quality will potentially be affected by the program, but any effects will not be long term. Insecticides may enter aquatic environments only during treatments adjacent to those environments or during rainfall events that generate runoff. All the insecticides considered for the program degrade rapidly and will quickly disappear from the aquatic environment and soils. In general, insecticide concentrations will be highest in aquatic environments adjacent to treated fields, such as farm ponds and small streams, but the concentrations will decrease with increased downstream distance in the watershed. Increased water volumes downstream help dilute dissolved insecticide. Rapid degradation of the proposed program insecticides further decreases the insecticide concentrations.

The GLEAMS model (Leonard et al., 1987, 1988) was used to determine water concentrations in undiluted field runoff. Cotton production soils, such as sandy loam, silt loam, sand, and loam, were examined. A detailed discussion of the modeling methodology and results is included in appendix A. According to the model, more than 60% of the insecticide residues in the runoff were found in the dissolved portion. The remainder were adsorbed to eroded sediments, which are less available for fish and wildlife intake. The insecticides are diluted immediately downstream of the point of discharge. This dilution will be sufficient in many cases to reduce insecticide concentrations to safe levels. Accordingly, maximum impacts to wildlife could occur closest to the point of runoff discharge.

GLEAMS and AGDISP were used to examine the effects of insecticide runoff and drift, respectively, on farm ponds. Farm ponds are particularly susceptible to drift deposition because of their large surface areas, shallow depths, proximity to cotton production areas, and long residence times (that is, the same water sits in the pond for long periods without the introduction of new water). A discussion of the potential impacts of the program on farm ponds is provided in chapter 4 of the Draft EIS for the cooperative control program.

EXAMS II estimated the riverine concentration of insecticides under the proposed eradication program. The model was used to examine concentrations of diflubenzuron, malathion, and methyl parathion in the Tennessee and Alabama Rivers during a storm event. At their peak, insecticide loadings in the modeled rivers were several orders of magnitude lower

than the maximum insecticide concentrations leaving the cotton fields. The water quality of the rivers is not expected to be significantly affected by the control program. A detailed discussion of the EXAMS II modeling methodology and results is presented in appendix A.

Results from the GLEAMS model were also used to examine the residues of the insecticides that remain in the soil on the field. The results of the analysis indicate that for all insecticides and all representative soil types, no cumulative buildup of residues in the soil is expected. In each year of the program, the maximum buildup of residues occurs at the end of the maximum application period and decreases rapidly. While the sandier soils exhibited residual pesticide longer than the other soils, no insecticide was present in any soils when the next application year began.

Groundwater Quality

The GLEAMS model output provided information on the potential of insecticides to leach below the root zone and possibly into the groundwater. The modeling results indicate that percolation through the soil (even during extreme storm events) is negligible, and no pesticide percolated through the root zone, which was modeled assuming a 40-inch (100-cm) depth. None of the insecticides reached a depth of more than 20 inches (50 cm). Malathion generally reached the highest concentrations in soils and migrated farthest downward through the soil, although it never reached the groundwater in significant quantities. As discussed previously, all of the insecticides readily degrade. They are also readily adsorbed to the soil. Based on these two processes and on the results of the GLEAMS model, none of the insecticides should reach the groundwater in any significant amount.

The Alabama Department of Environmental Management and the Alabama Department of Agriculture and Industries are conducting a groundwater monitoring study, the results of which will be used to develop a groundwater protection strategy for pesticide applications in Alabama. The monitoring for phase I of this study was completed in 1989. This phase sampled 50 private wells in 10 counties to determine occurrences of pesticides in groundwater. Each well was sampled in early May, late June or early July, and mid-August. In the 150 samples taken, only 1 sample contained a detectable concentration of malathion—0.09 parts per billion (ppb). This well was located in Colbert County. No diflubenzuron or methyl parathion was detectable in any samples. In phase II of this program, additional wells are being sampled in each county sampled in phase I. Another phase of the study will involve the installation of monitoring wells adjacent to cotton fields for a more complete picture of pesticide fate.

Human Health and Safety

Two groups of people may be affected by the proposed boll weevil control program in Alabama—workers and certain members of the public. The workers would include both APHIS program people and contract applicators involved in applying one of the three program insecticides or engaged in other boll weevil control activities. Members of the public may be affected only if they are present near the edge of a cotton field while it is being treated or if they consume food or water with insecticide residues. The program should not affect anyone else's health or safety.

Workers could be injured during operation of the aircraft, hiboys, or mist blowers used in the application of the

program insecticides. Growers could be injured during postharvest stalk destruction. There is some risk of fatalities from those injuries during applications, particularly in the case of an aircraft accident. Routine safety precautions that are among the standard operating procedures (chapter 2) for aircraft and farm equipment use should minimize the possibility of serious injuries or fatalities. The public is not at a significant risk of injury from these types of accidents.

There is some risk that workers and the public may become ill from being exposed to the program insecticides. In particular, malathion and methyl parathion are among the organophosphate pesticides known to interfere with the functioning of the human nervous system by binding to the enzymes involved in the transmission of nerve signals. Repeated smaller doses are effectively equivalent to a single large dose because this binding process is irreversible until the body has had enough time to manufacture additional enzymes. Diflubenzuron does not produce this effect. Sufficient enzyme inhibition can lead to symptoms of poisoning, such as headaches, nausea, and dizziness.

Fatalities may result from severe exposure if immediate treatment is not available, but the possibility of such an exposure would be limited to the workers who routinely handle large quantities of the insecticide concentrates. No member of the public is likely to receive such a high dose. There is also some evidence from laboratory animal studies that the control program insecticides might also produce longer term health effects, such as reproductive effects or cancer, in exposed individuals.

A risk assessment was conducted to evaluate the possible human health effects of the program insecticides. The risk assessment estimated insecticide doses that workers or members of the public might receive and compared those doses with dose levels found to produce no toxic effects in tests on human volunteers and laboratory rats. The details of the assumptions used to estimate each type of dose and the risk evaluation criteria are given in appendix A.

Worker and public doses were estimated from "typical" exposures in routine applications and from "extreme" exposures (that is, the highest doses likely in routine applications). Worker and public "accidental" doses were also estimated for a series of possible accidents, such as being directly sprayed by an aircraft or spilling insecticide concentrate on unprotected skin. These doses were estimated to cover the whole range of possible program insecticide exposures. Both estimated and laboratory dose levels were expressed on a daily basis as milligrams of insecticide per kilogram of body weight per day (mg/kg/day).

The risk assessment was conservative because the assumptions used in estimating the doses used the highest value from the range of a number of variables. For example, although wind speed during the actual applications will vary from calm to 10 mph, the typical public dose was assumed to occur with a person standing 100 feet downwind from a cotton field that is being aerially sprayed in a 10-mph wind, leading to an insecticide deposition of about 4% of the on-the-field rate on 2 square feet of the person's exposed skin. The extreme estimate had the person standing 25 feet from the field in the same wind conditions, and the drift amounted to about 11% of the onsite rate. Accidental exposures involving

dermal exposure assume that the exposed individual does not wash after being exposed but allows the insecticide to be absorbed. The risk assessment was also conservative in judging potential toxic effects because it compared the estimated doses to repeated human and rat doses that produced no effects, even though doses to the public should only occur rarely.

The risk assessment evaluated general systemic effects, such as cholinesterase inhibition, as well as effects on reproduction by comparing estimated doses to the no-observed-effect levels (NOELs) in laboratory animal reproduction studies. A margin of safety (MOS) was computed for each type of exposure by dividing the laboratory NOELs for systemic and reproductive effects by the estimated exposure. For example, if the NOEL is 25 mg/kg/day and the estimated dose is 0.1 mg/kg/day, the MOS is 250. A safety factor of 10 is usually applied for assessing risk from human studies, and an additional safety factor of 10 is usually applied for judging risk from laboratory animal studies.

For all calculations except systemic risks based on the human volunteer studies on malathion and methyl parathion, exposures resulting in MOSs equal to or greater than 100 are assumed to present a negligible risk to human health. An MOS between 10 and 100 represents a moderate risk. If the MOS is less than 10, it is assumed that there is a significant potential for adverse health effects. In the case of systemic risks based on human studies, EPA recommends using an uncertainty factor of 10, except for methyl parathion as discussed below. Therefore, in this risk assessment for malathion, an MOS equal to or greater than 10 represents a negligible risk, an MOS between 1 and 10 represents a moderate risk, and an MOS less than 1 is a significant risk. EPA recommends an uncertainty factor of 100 for the human studies on methyl parathion, so the MOS for risk evaluation is set at 100 for that chemical. Both malathion and methyl parathion were also evaluated in long-term feeding studies on rats. The NOELs from those studies are also listed in the human health risk tables. An MOS of 100 would be applied in these cases to indicate acceptable risk. Where an estimated dose exceeds a NOEL, the ratio is reversed and a minus sign added to give a "negative" margin of safety. A "-MOS" indicates a high probability of the risk of toxic effects.

Because a metabolite of malathion, malaoxon, has shown evidence of producing thyroid tumors in rats and diflubenzuron has shown evidence of producing lymph tumors in mice, a human cancer risk assessment was done for these two chemicals. This portion of the risk assessment took an estimate of the lifetime daily dose in mg/kg/day of the program insecticide (total of expected program doses divided by days in a 70-year lifetime) and multiplied it by the cancer potency of the chemical (expressed as per mg/kg/day) as determined from the laboratory tumor data. This provided a number between 0 and 1 that indicated the chances of developing cancer from that lifetime exposure. For example, if the estimated average lifetime dose is 0.0002 mg/kg/day and the cancer potency is 0.005 per mg/kg/day, the risk of developing cancer is 0.000001, or 1 in 1 million. Risks of 1 in 1 million or less are assumed to be acceptable.

Table 4-1 lists the doses, NOELs, and computed MOSs for the public and workers from typical program exposures to

malathion, methyl parathion, and diflubenzuron. Table 4-2 indicates the doses, NOELs, and computed MOSs for the public and workers from extreme program exposures. Table 4-3 shows doses, NOELs, and MOSs from various possible program accidents. Table 4-4 lists the control program lifetime cancer risks to workers and the public.

Public Health Risks

The risk assessment concluded that, in general, the program insecticides do not pose a risk to the public. Based on toxicity levels found in human studies on malathion and methyl parathion compared with expected "typical" program exposures, neither chemical is likely to cause health effects. Based on the results of studies in laboratory rats, however, methyl parathion does seem to pose a risk to anyone within 100 feet of a cotton field who is exposed to insecticide drift or to anyone who eats berries or legumes contaminated with methyl parathion. Diflubenzuron poses no risk of public health effects under normal exposure circumstances.

None of the program insecticides poses a risk of reproductive health effects to members of the public either as a result of "typical" exposures or "extreme" exposures, which are the highest exposures anyone is likely to receive from an insecticide application, other than those involved in an accident.

For malathion, there are moderate risks of systemic effects as a result of being directly sprayed, drinking 2 liters of water from a 16-acre reservoir into which an accidental release of 80 gallons of malathion occurred, and eating legumes that were directly sprayed. The risks of reproductive effects from malathion to members of the public from all accident scenarios are negligible. For diflubenzuron, the risks of systemic or reproductive effects as a result of accidents are also negligible. For methyl parathion, there are significant risks of systemic effects and moderate risks of reproductive effects from being directly sprayed, drinking water from a 16-acre reservoir contaminated by a release, and eating berries or legumes that were directly sprayed.

Cancer risks to members of the public were evaluated to be less than 1 in 1 million for all exposures from malathion or diflubenzuron under both typical and extreme exposure scenarios. Therefore, negligible cancer risks to the public are expected to result from public exposure to these insecticides as a result of the boll weevil control program in Alabama.

Worker Health Risks

Risks to workers who are routinely involved in program insecticide applications are understandably higher. Based on effect levels seen in human studies, both malathion and methyl parathion seem to pose a risk to hiboy and mist blower applicators in routine applications. Based on a rat study, diflubenzuron also presents a risk to hiboy and mist blower operators. Workers in aerial applications are at a lower risk. Malathion and diflubenzuron do not present a risk to aerial applicators; based on the rat study toxicity level, however, methyl parathion does.

Table 4-1. Estimated doses and margins of safety for TYPICAL EXPOSURE to the public and workers in Alabama from boll weevil insecticides

Exposure	Malathion (all doses in mg/kg/day)				Methyl parathion (all doses in mg/kg/day)				Diflubenzuron (all doses in mg/kg/day)			
	Estimate of exposure	Human NOEL[a] (MOS)	Rat NOEL[b] (MOS)	Repro. NOEL[c] (MOS)	Estimate of exposure	Human NOEL[d] (MOS)	Rat NOEL[e] (MOS)	Repro. NOEL[f] (MOS)	Estimate of exposure	Human NOEL[g] (MOS)	Rat NOEL[h] (MOS)	Repro. NOEL[i] (MOS)
Public: Dermal/inhalation	0.00141	0.23 (163)	5.0 (3,546)	25 (10,000)[j]	0.000727	0.31 (426)	0.025 (34)	0.25 (344)	0.00019	N/A[k]	1.0 (5,263)	>8.0 (10,000)
Dietary: Water	0.00000787	0.23 (10,000)	5.0 (10,000)	25 (10,000)	0.00000143	0.31 (10,000)	0.025 (10,000)	0.25 (10,000)	0.000000226	N/A	1.0 (10,000)	>8.0 (10,000)
Fish	0.0000728	0.23 (3,158)	5.0 (10,000)	25 (10,000)	0.0000312	0.31 (9,936)	0.025 (801)	0.25 (8,014)	0.00000566	N/A	1.0 (10,000)	>8.0 (10,000)
Venison	0.0000134	0.23 (10,000)	5.0 (10,000)	25 (10,000)	0.00000561	0.31 (10,000)	0.025 (4,455)	0.25 (10,000)	0.00000141	N/A	1.0 (10,000)	>8.0 (10,000)
Legumes	0.00119	0.23 (193)	5.0 (4,202)	25 (10,000)	0.00051	0.31 (607)	0.025 (49)	0.25 (490)	0.000129	N/A	1.0 (7,778)	>8.0 (10,000)
Berries	0.000597	0.23 (385)	5.0 (8,375)	25 (10,000)	0.000255	0.31 (1,216)	0.025 (98)	0.025 (980)	0.0000643	N/A	1.0 (10,000)	>8.0 (10,000)
Workers: Pilot	0.00326	0.23 (71)	5.0 (1,534)	25 (7,666)	0.00168	0.31 (184)	0.025 (15)	0.25 (148)	0.000421	N/A	1.0 (2,376)	>8.0 (10,000)
Mixer/loader	0.0009	0.23 (256)	5.0 (5,556)	25 (10,000)	0.000466	0.31 (665)	0.025 (54)	0.25 (536)	0.000117	N/A	1.0 (8,579)	>8.0 (10,000)
Observer	0.00556	0.23 (41)	5.0 (899)	25 (4,498)	0.00326	0.31 (95)	0.025 (8)	0.025 (77)	0.00147	N/A	1.0 (679)	>8.0 (5,435)
Evaluation team	0.00556	0.23 (41)	5.0 (899)	25 (4,498)	0.00326	0.31 (95)	0.025 (8)	(0.25) (77)	0.00147	N/A	1.0 (679)	>8.0 (5,435)
Hiboy operator	0.100	0.23 (2)	5.0 (50)	25 (250)	0.122	0.31 (3)	0.025 (-5)	0.25 (2)	0.121	N/A	1.0 (8)	>8.0 (66)
Mist blower operator	0.120	0.23 (2)	5.0 (42)	25 (208)	0.123	0.31 (3)	0.025 (-5)	0.25 (2)	0.110	N/A	1.0 (9)	>8.0 (73)

[a]Source: EPA, 1988b.
[b]Source: EPA, 1988b.
[c]Source: EPA, 1988d.
[d]Source: EPA, 1987.
[e]Source: EPA, 1988a.
[f]Source: EPA, 1988g.
[g]No information was available.
[h]Source: EPA, 1988b.
[i]Source: EPA, 1988a.
[j]Where an MOS equals or exceeds 10,000, the value 10,000 is placed in the table.
[k]No studies of diflubenzuron in humans were available.

Table 4-2. **Estimated doses and margins of safety for EXTREME EXPOSURE to the public and workers in Alabama from boll weevil insecticides**

Exposure	Malathion (all doses in mg/kg/day)				Methyl parathion (all doses in mg/kg/day)				Diflubenzuron (all doses in mg/kg/day)			
	Estimate of exposure	Human NOEL[a] (MOS)	Rat NOEL[b] (MOS)	Repro. NOEL[c] (MOS)	Estimate of exposure	Human NOEL[d] (MOS)	Rat NOEL[e] (MOS)	Repro. NOEL[f] (MOS)	Estimate of exposure	Human NOEL[g] (MOS)	Rat NOEL[h] (MOS)	Repro. NOEL[i] (MOS)
Public:												
Dermal/ inhalation	0.00477	0.23 (63)	5.0 (1,048)	25 (6,868)	0.00187	0.31 (166)	0.025 (13)	0.25 (134)	0.000477	N/A	1.0 (2,096)	>8.0 (10,000)
Dietary:												
Water	0.0000193	0.23 (10,000)	5.0 (10,000)	25 (10,000)	0.000000231	0.31 (10,000)	0.025 (10,000)	0.25 (10,000)	0.0000000576	N/A	1.0 (10,000)	>8.0 (10,000)
Fish	0.000178	0.23 (1,289)	5.0 (10,000)	25 (10,000)	0.00000502	0.31 (10,000)	0.025 (4,985)	0.25 (10,000)	0.00000144	N/A	1.0 (10,000)	>8.0 (10,000)
Venison	0.00015	0.23 (1,533)	5.0 (10,000)	25 (10,000)	0.0000639	0.31 (4,851)	0.025 (391)	0.25 (3,914)	0.000016	N/A	1.0 (10,000)	>8.0 (10,000)
Legumes	0.0031	0.23 (74)	5.0 (1,613)	25 (8,059)	0.00133	0.31 (233)	0.025 (19)	0.25 (188)	0.000333	N/A	1.0 (3,006)	>8.0 (10,000)
Berries	0.00155	0.23 (148)	5.0 (3,226)	25 (10,000)	0.000663	0.31 (468)	0.025 (38)	0.25 (377)	0.000166	N/A	1.0 (6,012)	>8.0 (10,000)
Workers:												
Pilot	0.00783	0.23 (29)	5.0 (639)	25 (3,194)	0.00405	0.31 (77)	0.025 (6)	0.25 (62)	0.00101	N/A	1.0 (987)	>8.0 (7,899)
Mixer/loader	0.00471	0.23 (49)	5.0 (1,061)	25 (5,304)	0.00245	0.31 (126)	0.025 (10)	0.25 (102)	0.000612	N/A	1.0 (1,635)	>8.0 (10,000)
Observer	0.0394	0.23 (6)	5.0 (127)	25 (635)	0.0152	0.31 (20)	0.025 (2)	0.25 (16)	0.00322	N/A	1.0 (311)	>8.0 (2,486)
Evaluation team	0.0394	0.23 (6)	5.0 (127)	25 (635)	0.0152	0.31 (20)	0.025 (2)	0.25 (16)	0.00322	N/A	1.0 (311)	>8.0 (2,486)
Hiboy operator	0.886	0.23 (-4)	5.0 (6)	25 (28)	1.08	0.31 (-3)	0.025 (-43)	0.25 (-4)	1.08	N/A	1.0 (-1)	>8.0 (7)
Mist blower operator	0.241	0.23 (0)	5.0 (20)	25 (104)	0.259	0.31 (0)	0.025 (-10)	0.25 (0)	0.239	N/A	1.0 (4)	>8.0 (33)

[a]Source: EPA, 1988b.
[b]Source: EPA, 1988b.
[c]Source: EPA, 1988d.
[d]Source: EPA, 1987.
[e]Source: EPA, 1988a.
[f]Source: EPA, 1988g.
[g]No information was available.
[h]Source: EPA, 1988b.
[i]Source: EPA, 1988a.

Table 4-3. Estimated doses and margins of safety for ACCIDENTAL EXPOSURE to the public and workers in Alabama from boll weevil insecticides

Exposure	Malathion (all doses in mg/kg/day)				Methyl parathion (all doses in mg/kg/day)				Diflubenzuron (all doses in mg/kg/day)			
	Estimate of exposure	Human NOEL[a] (MOS)	Rat NOEL[b] (MOS)	Repro. NOEL[c] (MOS)	Estimate of exposure	Human NOEL[d] (MOS)	Rat NOEL[e] (MOS)	Repro. NOEL[f] (MOS)	Estimate of exposure	Human NOEL[g] (MOS)	Rat NOEL[h] (MOS)	Repro. NOEL[i] (MOS)
Accidents:												
Spill of concentrate	0.0241	0.23 (-1,050)	5.0 (-48)	25 (-10)	0.633	0.31 (-204)	0.025 (-2,533)	0.25 (-253)	0.662	N/A	1.0 (-66)	>8.0 (-8)
Broken hose	0.0241	0.23 (-1,050)	5.0 (-48)	25 (-10)	0.317	0.31 (-102)	0.025 (-1,267)	0.25 (-127)	0.165	N/A	1.0 (-17)	>8.0 (-2)
Immediate field entry	0.000469	0.23 (490)	5.0 (10,000)	25 (10,000)	0.000572	0.31 (542)	0.025 (44)	0.25 (437)	0.000572	N/A	1.0 (1,748)	>8.0 (10,000)
Direct spray–adult	0.0285	0.23 (8)	5.0 (175)	25 (877)	0.0149	0.31 (21)	0.025 (2)	0.25 (17)	0.00372	N/A	1.0 (269)	>8.0 (2,153)
Drinking reservoir water/release	1.0744	0.23 (3)	5.0 (67)	25 (336)	0.008	0.31 (39)	0.025 (3)	0.25 (31)	0.00418	N/A	1.0 (239)	>8.0 (1,913)
Eating berries–direct spray	0.0134	0.23 (17)	5.0 (373)	25 (1,870)	0.000571	0.31 (54)	0.025 (4)	0.25 (44)	0.00143	N/A	1.0 (700)	>8.0 (5,600)
Eating legumes–direct spray	0.0267	0.23 (9)	5.0 (187)	25 (935)	0.0114	0.31 (27)	0.025 (2)	0.25 (22)	0.00286	N/A	1.0 (350)	>8.0 (2,800)

[a]Source: EPA, 1988b.
[b]Source: EPA, 1988b.
[c]Source: EPA, 1988d.
[d]Source: EPA, 1987.
[e]Source: EPA, 1988a.
[f]Source: EPA, 1988g.
[g]No information was available.
[h]Source: EPA, 1988b.
[i]Source: EPA, 1988a.

Table 4-4. Control program lifetime cancer risks

Exposure scenario	Risk	
	Malathion[a]	Diflubenzuron[b]
Public:		
Dermal and inhalation:		
Drift	.00000000208	.00000000126
Dietary:		
Water	.0000000000133	.00000000000141
Fish	.000000000123	.0000000000352
Venison	.0000000000398	.0000000000193
Legumes	.00000000204	.000000000100
Berries	.00000000102	.000000000501
Workers:		
Pilot	.000000230	.0000000242
Aerial mixer/loader	.0000000792	.00000000838
Observer/environmental evaluation team	.000000312	.0000000465
Hiboy operator	.00000733	.00000745
Mist blower operator	.00000460	.00000347
Accidents:		
Spill of concentrate	.0000481	.0000603
Broken hose	.0000481	.0000241
Immediate field reentry	.0000000000516	.000000000287
Directory spray-adult	.00000000420	.00000000250
Direct reservoir water/release	.0000000110	.00000000281
Eating berries-direct spray	.00000000197	.000000000961
Eating legumes-direct spray	.00000000394	.00000000192

[a]Cancer risks are based on a cancer potency value of 0.00376 $(mg/kg/day)^{-1}$.
[b]Cancer risks are based on a cancer potency value of 0.01718 $(mg/kg/day)^{-1}$. The carcinogenicity information on diflubenzuron is inconclusive; however, because positive results were obtained in one study, a cancer risk analysis was conducted.

Note: Risk calculations assume typical exposure 90% of the time and extreme exposure 10% of the time.

Reproductive risks to workers as a result of typical exposures to malathion are negligible. There are moderate risks of reproductive effects from typical exposures to diflubenzuron for hiboy and mist blower operators. Typical exposures to methyl parathion pose a moderate risk of reproductive effects to observer/environmental evaluation (EE) team workers and significant risks of reproductive effects to hiboy and mist blower operators.

For extreme exposures to malathion, there is a moderate risk of systemic effects to observer/EE workers, a significant risk of systemic effects to hiboy and mist blower operators, and a moderate risk of reproductive effects to hiboy operators. Extreme exposures to diflubenzuron pose a significant systemic risk to hiboy and mist blower operators, a significant reproductive risk to hiboy operators, and a moderate reproductive risk to mist blower operators. Methyl parathion presents moderate risks of systemic effects from extreme exposures to mixer/loaders and of reproductive effects to pilots and observer/EE workers. Extreme exposures to methyl parathion also pose a significant systemic risk to pilots, observer/EE workers, and hiboy and mist blower operators and a significant reproductive risk to hiboy and mist blower operators.

Malathion, diflubenzuron, and methyl parathion present significant systemic and reproductive risks from a spill of concentrate on the skin or spray from a broken hose. Additionally, methyl parathion poses a moderate risk of systemic effects from immediate reentry to a treated area.

Malathion presents a cancer risk to hiboy and mist blower operators of about 7 in 1 million and 5 in 1 million, respectively. Cancer risk also exceeds 1 in 1 million for exposure to diflubenzuron in hiboy operators (7 in 1 million) and mist blower operators (3 in 1 million). All other workers have potential cancer risks of less than 1 in 1 million. Accidental exposures to workers can also result in elevated cancer risk probabilities. Risks from malathion are about 50 in 1 million for a spill of concentrate or spray from a broken hose. Estimated cancer probabilities as a result of diflubenzuron exposure are 6 in 100,000 for a spill of concentrate on the skin and 2 in 100,000 for being sprayed from a broken hose. For both insecticides, cancer risks are less than 1 in 1 million for immediate reentry to a treated area.

Mitigation Measures To Protect Human Health

The public seems to be at some level of risk from program applications of methyl parathion. Measures to mitigate this risk are presented in table 2-1 of the Draft EIS.

Workers following label directions and standard operating procedures for insecticide applications are generally well protected from the extreme and accidental exposures evaluated here. Hiboy and mist blower operators who seem to be at the greatest risk would be adequately protected if they work only in a closed-system, air-conditioned cab.

Economics

Economic Impacts

This section describes the potential direct and indirect economic impacts of implementing the cooperative control program in central and northern Alabama.

Direct Impacts

Alabama depends on agriculture and related industries for employment and revenues (chapter 3, "Economics"). The direct economic impacts of the proposed eradication program in Alabama consist of increased employment and sales of treatment materials. The subsequent increase in personal incomes and revenues would benefit the economy of the state if the employees and needed materials are acquired within Alabama.

Mist blower and hiboy operators, trappers, field unit supervisors, air operations personnel, and Plant Protection and Quarantine (PPQ) officers will be required for the control program in central and northern Alabama. A total of 707 jobs should be available for residents, some of whom would otherwise be unemployed (table 4-5). The payroll from these positions during the 2½-year active eradication phase and 1-year posteradication surveillance is estimated to be approximately $19 million. The contractor responsible for aerial pesticide application provides all the required labor, and although the contractors are usually local residents, this may not always be the case.

Table 4-5. Potential employment opportunities

Job categories	Central	North	Total
Mist blower operators	22	45	67
Hiboy operators	3	8	11
Trappers	105	223	328
Field unit supervisors	22	45	67
Air operations	63	129	192
Clerical	5	10	15
Miscellaneous	9	18	27
Total	229	478	707

Expenditures for the pesticide, traps (including stakes, kill strips, and pheromone chips), and reimbursable mileage are estimated at $15 million over the 3½-year program. All equipment used in the program is owned by the federal government, so it is unlikely that any major capital expenditures would be made within the state as a result of the program. However, any replacement parts required for repairs and fuel would be purchased in Alabama; the value of these expenditures cannot easily be approximated.

Indirect Impacts

Each year between 1981 and 1984, Alabama cotton growers spent an average of $54.48 per harvested acre to control boll weevil and *Heliothis* spp. During that period, the average annual cost of controlling all cotton insects and mites was $65.32 per harvested acre.

Eradicating the boll weevil in Alabama is expected to decrease the cost of producing cotton by decreasing expenditures for cotton insecticides used to control the boll weevil and secondary pests. The nonfederal share of the projected cost of expanding the program in Alabama should be less than $25 per acre. The amount the grower actually pays can be reduced by funding from other nonfederal sources.

After eradication, the nonfederal share of program costs would likely be reduced to less than $10 per acre. Compared with the previous cost of controlling the boll weevil, this should result in the potential for increasing grower profits. Such an increase in profit could lead to a 20 to 25% increase in cotton acreage, replacing soybeans or corn (Smith, 1990). Insecticide costs have been reduced and yields increased as a result of boll weevil eradication elsewhere in the southeastern United States. In North and South Carolina insecticide savings are $29 per acre, and yield has increased 69 pounds per acre (USDA, 1989).

The long-term effects of an increase in cotton production include reductions in the market price of cotton lint, seed, cottonseed oil, and reduction of the government support price (NRC, 1981). New jobs may also become available in cotton-related industries, such as harvesting (pickers and balers), processing (cotton gins), and textile industries.

Socioeconomic Impacts

The boll weevil control program could have direct and indirect impacts on the social conditions and attitudes in Alabama. Direct impacts could occur if a grower's sense of well-being or economic security were affected by eradication. Indirect effects could occur as a result of economic outcomes of eradication. For example, reactions to the increase in cotton production and job availability are social effects derived from economic impacts. All of these impacts, direct and indirect, could affect lifestyles and community stability.

An earlier subsection described the direct impacts of the control program on employment and personal income. The economic impacts on individuals who obtain jobs or profit from the sale of materials would be the same wherever they live. Social effects, however, would depend on whether the jobs and profits gained were concentrated or dispersed throughout small or large communities. For example, the gain of 100 jobs scattered around the larger cities of Alabama would not have significant social effects. In contrast, if those 100 jobs were concentrated in two small towns with a combined labor force of 500, there would be significant social impacts on the two communities. The jobs available as a result of the control program would be scattered throughout the small towns of central and northern Alabama.

Residents of the small rural communities where cotton is grown provide all the labor necessary for cotton production and related local industries. The unemployment rate is higher in these rural areas than in the rest of Alabama (chapter 3), so any employment opportunities resulting from the central and northern control program would be important to those communities.

Many of the social effects of the eradication program may occur as a result of increases in jobs and personal income. Compared with Alabama's total employment and total personal income, employment and income changes resulting from the control program in central and northern Alabama may seem small. However, if considered on a local basis, these changes may be important to individuals who rely on the continued productivity of cotton and employment in related industries for their livelihood.

Opposition to the Program

The decision to implement the control program in central and northern Alabama would ultimately be made by the growers' approval of the program by grower referendums. Passage of the referendums in the rest of the state depends on the growers' conviction that the program will work and that it is worth the cost.

Some growers who believe they can control the boll weevil on their fields for less than the cost of the program may be opposed to its implementation in central and northern Alabama. In some cases the growers' current annual control costs may be less than an annual grower assessment required by the national program. However, after the program has eradicated the boll weevil, grower control costs for the boll weevil should be eliminated. Without the program, the growers will continue to incur direct and indirect costs for boll weevil control each and every year.

Growers could also be opposed to the program if they perceive that a portion of their control over their cotton crop is being taken from them and given to the federal government. This opposition may be reduced by the fact that all program activities conducted on the farms will be performed by local residents employed by the program.

Public opposition to implementation of the program is likely to be most intense in rural communities or areas closest to cotton fields but could also occur in more distant areas. Whenever these issues arise, they will be considered on a local level. Appropriate public participation and other information efforts would likely mitigate any possible negative social effects.

Costs of Boll Weevil Controls

This section describes the methodology and assumptions used to estimate the costs of implementing the next increment of the control program in central and northern Alabama (table 4-6). The materials, equipment, and labor requirements for program expansion are presented, along with the costs of each. These costs are estimates based on expected resource requirements; actual costs would depend on other factors that cannot be predicted, such as the weather, actual boll weevil densities, and changes in material and labor costs. All costs are based on the current costs of the southern Alabama eradication program and allow for an annual rate of inflation of 4.1%. It is assumed that the federal share of program costs will remain at 30%.

The control program in central and northern Alabama would consist of an active eradication phase and posteradication surveillance. It is expected to continue for a total of 3½ years—an initial fall diapause treatment followed by 2 full years of active treatment in both areas of the state and 1 year of posteradication surveillance.

Chemical Control and Trap Surveying

The insecticides proposed for use in central and northern Alabama are malathion, diflubenzuron, and methyl parathion. The total cost of chemical control consists of the cost of insecticides, contracts for the aerial application of the insecticides (including aircraft, pilots, and mixer/loaders), and wages associated with monitoring and ground application.

The program would begin in the late summer in both central and northern Alabama. It is expected that an average of eight diapause treatments would be applied to up to 80% of the cotton acreage in central Alabama, and an average of four treatments would be applied to up to 60% of the cotton in northern Alabama (table 4-7). Some trapping will be done before and during this period.

The overall density of trapping would increase the following spring to an average of one trap per 1 to 2 acres. Treatments would be applied during the growing season when the designated threshold for boll weevils is exceeded. These treatments will control boll weevil reproduction and prevent economic damage to the crop. Fall diapause treatments would again be applied, where needed, to significantly reduce the overwintering boll weevil population.

Table 4-6. Estimated boll weevil eradication costs[a] in central and northern Alabama

Category	Central Alabama		Northern Alabama[b]		Total
	Total costs	Costs per acre	Total costs	Costs per acre	
Personnel	$6,498,320	$64.13	$12,283,642	$50.54	$18,781,962
Pesticide	3,409,050	33.64	4,813,006	19.80	8,222,056
Aerial application	2,315,227	22.85	3,256,855	13.40	5,572,082
Traps/lures	1,208,613	11.93	2,786,424	11.46	3,995,037
Other	2,563,729	25.30	5,689,085	23.41	8,252,814
Total	$15,994,939	$157.85	$28,829,012	$118.61	$44,823,951
Nonfederal share (70%)	$11,196,457	$110.50	$20,180,308	$83.03	$31,376,765
Federal share (30%)	$4,798,482	$47.35	$8,648,704	$35.58	$13,447,185

[a]Assumes an annual rate of inflation of 4.1% in 1991 and 1992.
[b]Total costs for northern Alabama include adjacent program areas in Tennessee and Georgia.

Table 4-7. Average insecticide treatment schedule

Year	Central Alabama		Northern Alabama	
	Number of treatments	Percent of acreage	Number of treatments	Percent of acreage
1—Fall	8	80	4	60
2—Spring	4	25	2	20
2—Summer	4	8	4	5
2—Fall	8	35	6	30
3—Spring	3	10	3	7
3—Summer	4	5	4	2
3—Fall	8	20	6	15
4—Confirmation period	2	5	2	5

During the 2½-year eradication effort, one of the most intense periods will be during September of the first year. Although most fields may require treatment at this time, the percentage of fields treated will decrease rapidly with each treatment cycle. Growers will be offered incentives for early harvest and stalk destruction. Cooler temperatures in October will accelerate harvesting operations and allow longer treatment intervals. These factors will contribute to a continual decrease in the percentage of fields treated from one treatment cycle to the next.

During this period, the effect of rainfall is expected to be minimal. Appreciable rainfall does not usually occur until later in November and December after diapause treatments and harvesting. In northern Alabama, more than 95% of the cotton crop is harvested by late October.

During the season, cotton acreage may be treated aerially using fixed-wing aircraft or with ground equipment. The edges of the fields are trimmed aerially whenever possible. However, when the edges are obstructed by trees, power lines, or buildings or are near sensitive areas, such as the habitats of endangered or threatened species, the pesticide would be applied using a mist blower mounted on the back of a truck. Approximately 2% of the cotton acreage in central or northern Alabama could not be treated aerially because of physical obstructions or proximity to sensitive areas; a hiboy tractor or mist blower would be used to treat these acres.

Aerial Application and Mist Blower Trim. The 55-gallon barrels of malathion used for aerial and mist blower application in southern Alabama cost approximately $15.50 per gallon, or $1.94 per acre. This figure assumes an application rate of 16 ounces per acre; 1 gallon will treat 8 acres. Although diflubenzuron and methyl parathion may be used in the program, the pesticide costs for the next increment of the program in central and northern Alabama are based on the current cost of malathion because it is the only pesticide used in southern Alabama and is expected to be used in central and northern Alabama. As noted in the discussion of

national boll weevil control costs found in volume 1 of the Draft EIS, based on bids received from chemical companies, the per acre cost of methyl parathion was only slightly less than for malathion. In addition, diflubenzuron is generally more than twice as expensive as methyl parathion or malathion. If diflubenzuron is used in Alabama, it would only be used two to four times in June.

The quantity of pesticide applied aerially is calculated on the total acreage of the field plus 5% for trim. Contract application of malathion costs approximately $10.53 per gallon, and the cost of the chemical plus application is approximately $3.40 per acre, including the 5% for trim. The contractor provides the aircraft, pilots, and ground crew. The salaries and benefits of personnel monitoring the aerial applications are estimated at $0.06 per acre per application. (Reimbursable mileage for these personnel are included in "Other Control Costs.")

Mist Blower Trim. Because the edges of some of the aerially treated cotton acreage are inaccessible by air, they will be trimmed by a mist blower mounted on the back of a truck rather than by aircraft. The acreage of these areas is estimated to be approximately 12.5% of the aerially treated acres. This percentage is equivalent to the proportion of an average 35-acre square field that could be treated by a 40-foot swath around the perimeter.

The total cost of the pesticide ($1.94 per acre) and the labor cost of application ($2.78 per acre) add up to $4.72 per acre. The pesticide cost would be the same as for aerial application. The cost of the mist blower operator is calculated on an 8-hour workday, 5 days a week for 28 weeks, at a wage rate of $6.20 per hour. One mist blower operator would be required for each 5,000 acres of cotton trimmed using this equipment. The mist blowers and trucks are owned by the federal government.

Ground Application With Hiboys. In Alabama about 2% of the cotton acreage requiring treatment each season would be treated using only ground equipment. The cost of the pesticide and labor is estimated at $4.08 per acre ($2.00 per acre for pesticide and $2.08 per acre for the hiboy operator). The 5-gallon barrels of malathion RTU used for hiboy application cost $16.00 per gallon; 1 gallon will treat 8 acres. The hiboy tractors are owned by the federal government. The $2.08 per acre cost of the hiboy operators is based on each operator working 6 hours per day, 5 days per week for 28 weeks, at a wage rate of $6.20 per hour. One hiboy operator would be needed for each 1,000 to 1,500 acres of cotton not treated by aircraft.

Trap Surveying. During the active phase of the program, traps used to estimate population densities would be placed every 100 to 125 feet along a field's perimeter and every 200 feet at the open ends of the field, for an average of one trap per acre.

A complete pheromone trap costs approximately $1.11 to $0.90 for the trap, $0.02 for the kill strip, $0.10 for the pheromone chip, and $0.09 for the stake. The kill strip will last all season, but the pheromone chip must be replaced every 2 weeks from mid-May until mid-November (10 times during the growing season). The per acre cost for the pheromone ($1.00 each season) is estimated separately from the cost for the rest of the trap ($1.01 per acre)

because approximately 30% of the traps are damaged by farm equipment or are dislodged from the stake and lost in the field each year and must be replaced. In addition, exposure to weather limits the traps' durability to 12 months in the fields or two growing seasons. At the end of each season, most of the traps would be collected and stored until the following spring.

One trapper would generally be hired for every 1,000 acres of cotton planted. Trappers work from early April until the end of November and earn $180 per week their first year and $200 per week in subsequent years. The cost per acre for this 28-week period, assuming half of the trappers are experienced and half are new, would be $5.32. An additional $2.50 per acre would be incurred for mileage reimbursement.

Other Control Costs

Other incurred expenses are not directly attributable to a treatment method. These program costs include USDA personnel, travel, relocation costs, utilities, services, repairs, supplies, and field unit supervisors (one for each 5,000 acres of cotton).

Posteradication Surveillance

During the posteradication phase, there would be one trap every 10 acres or two traps per field, whichever is greater. Trap costs at an average density of one trap every 7 acres would be $0.14 per acre. Replacement of the pheromone chips 10 times during the growing season would cost an additional $0.14 per acre. Monitoring costs are estimated to be $5 per acre per year, including travel. In addition, one PPQ officer might be employed for every 80,000 acres to supervise the trapping and communicate with cooperators each season. At a General Schedule level 9/5 ($28,001 annually), this is equivalent to $0.12 per acre.

Cultural Resources

The next increment of the eradication program in Alabama is not expected to have an impact on cultural resources. Cultural artifacts that may have existed on farm land have already been disturbed, removed, or destroyed by farming practices so the program treatments would not have any additional impact. There may be an increase in acres planted in cotton as a result of eradication. However, these additional acres are expected to result from the conversion of land already cleared and devoted to other crops, according to a personal communication with Smith (1990). No new clearing of land is expected; therefore, undiscovered cultural resources would not be disturbed.

Pesticide applications should not affect nearby cultural sites, such as the prehistoric Indian mounds or historic plantation homes described in chapter 3. The three counties with the greatest number of sites listed on the National Register of Historic Places—Montgomery, Jefferson, and Mobile—produce relatively little cotton (fig. 3-14). Aircraft used by the program are small and, if flying over a cultural site en route to a cotton field, would be at altitudes (as required by the Federal Aviation Administration—1,000 feet above any obstacle in congested areas, 500 feet above any structure in noncongested areas) high enough to avoid any disturbing noise.

Visual Resources

The fluorescent green traps used in monitoring boll weevil populations may be visually unappealing and distracting to some people.

Also, there may be a temporary increase in the visibility of agricultural airplanes for spray operations because some areas now treated by growers with ground equipment might be treated aerially. However, the sight of agricultural aircraft is common in Alabama's rural areas. In several years, the program will eliminate the need for aerial pesticide treatments for the boll weevil.

Air Quality

Pesticide treatments in central and northern Alabama require ground equipment and aircraft that emit pollutants. Total emission levels from each source are likely to change in the next increment because some acres that growers treat with ground equipment might be treated aerially. This increase in aerial emissions would be offset by the decrease in ground equipment emissions to some degree, so it is not expected to significantly affect Alabama's air quality. All areas not meeting federal standards for regulated air pollutants in 1989 were in urban areas (chapter 3).

Malathion has an odor that may offend anyone near a sprayed cotton field. However, malathion used in the next increment should not result in any significant additional impacts because some growers in the region already use it, the odor dissipates a short time after application, and the people likely to be near enough to a cotton field to smell it would be growers and others accustomed to the smell.

Noise

Noise from farm machinery and pesticide application equipment is a common sound in the agricultural areas of Alabama. Therefore, no additional noise impacts are expected in the next increment.

Energy Requirements and Conservation Potential

Fuel use in the next increment of the program will result from transporting personnel, materials, and equipment to a treatment area. Fuel is also used by aircraft and other equipment during the treatments. The principal fuels used are gasoline, diesel fuel, and aviation fuel.

With the program, there is a greater potential to conserve fuel than with existing grower practices. More acreage would probably be treated aerially at one time, as opposed to treating the acreage at each separate grower's request. This would reduce the trips to and from the airport and thereby reduce the airplanes' fuel requirements. Also, the ULV method of application used by the program allows pilots to treat more acres per hour of aircraft operation.

Cumulative Impacts

According to the CEQ regulations (40 CFR 1508.7), "cumulative impact" is the impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions. Cumulative impacts can result from the occurrence of individually minor but collectively significant actions over a period of time.

In addition to the insecticide applications of the program, growers will continue to use other broad-spectrum insecticides to control other cotton insect pests, as well as a number of herbicides for weed control and defoliation before harvest. Even though the program insecticides are

short-lived in the environment, some of the treatments may overlap with independent treatments, resulting in a short-term accumulation of pesticides in the environment.

Also, other pesticides may be used on noncotton crops, such as soybeans, corn, and peanuts, on farmland adjacent to program cotton fields. These chemicals include herbicides and insecticides. Some of the insecticides used on adjacent farmland may have a remote chance of synergistic effects with program insecticides. The program has no control over pesticide use on nonprogram fields, but if this usage complies with all label restrictions, there should be no significant synergistic or cumulative effects.

While the insecticides used in the program are not expected to have a lasting effect on water quality, these insecticides (in addition to other pesticides that growers may use) could create an overall pesticide burden that could put local streams, rivers, and farm ponds at risk. Farm ponds and the aquatic life they support may be especially adversely affected in the late summer months. High water temperatures greatly influence the potential impacts by increasing the metabolism of aquatic organisms, which in turn increases their food intake and thus their pesticide intake if the food is contaminated.

Ponds are also subject to volume reduction during the summer because increased evaporation rates and decreased precipitation serve to concentrate any nonvolatile, soluble contaminants in the water. The lower volume of water also provides less dilution potential if pesticides from drift, direct spray, or runoff enter the pond.

There are cumulative health risks to the workers who routinely conduct treatment operations. It is assumed that some of the applicators relocate with each increment of the National Boll Weevil Cooperative Control Program, and other workers may apply pesticides for other forestry, agricultural, and industrial programs. These individuals may be exposed to a wider range of pesticides than others normally would as a result of the program and may therefore have increased health risks. In particular, the organophosphate insecticides are acetylcholinesterase (AChE) inhibitors. The exposed human or animal remains susceptible to relatively low dosages of organophosphate chemical until the cholinesterase level has regenerated (Sax, 1984). AChE inhibition is cumulative in that if a worker or other member of the public has some level of inhibition, small doses of organophosphate chemicals at frequent intervals will have a partial additive effect.

Effects With Other Federal Programs

The next increment of the national program, as with all previous increments, will be conducted on privately owned cropland. Currently, no other federal or state programs are occurring in Alabama that might coincide with the next increment.

There is, however, an Imported Fire Ant Regulatory Program with no expected cumulative impacts because it is regulatory in nature, as opposed to an active control program. This program recommends using hydramethylnon and fenoxycarb (in the form of bait on corn cob grit), diazinon or chlorpyrifos as a drench on nursery stock, and chlorpyrifos on sod farms to kill imported fire ants before shipping the sod to unregulated areas. However, diazinon and chlorpyrifos are

organophosphate insecticides. If a sod farm or nursery were adjacent to cotton fields, and the treatments coincided or were done within a short period of one another, workers may experience the AChE effects described above.

Synergistic Effects

Volume 1 of the Draft EIS contains a full discussion of the synergistic potential of the insecticides to be used in the proposed next increment of the National Boll Weevil Cooperative Control Program. However, the discussion provided on azinphos-methyl does not apply because that chemical will not be used in Alabama.

Unavoidable Adverse Environmental Effects

An unavoidable adverse impact of the next increment is the temporary population reduction among a variety of beneficial arthropods, including ladybird beetles, minute pirate bugs, ambush bugs, parasitic wasps, lacewings, spiders, and predatory mites. However, these populations will begin to recover after the treatments end. The rapidity of recovery depends upon many factors, including food availability, fecundity, and number of generations per year.

Late-season treatments, as used in the boll weevil diapause control program in the Texas high plains, have been shown to have no significant effect on the population of biological control agents present the following spring. This has been attributed to the fact that treatments occur when the beneficial arthropods are not present in substantive numbers in the fields.

Irreversible and Irretrievable Commitment of Resources

The time, labor, and expenses of the next increment represent an irreversible and irretrievable commitment of government resources. The section on the costs of expansion of the program, discussed earlier in this chapter, contains a detailed analysis of the specific costs of this program, all of which are an irreversible and irretrievable commitment of resources. The petroleum products and insecticides used are additional irreversible and irretrievable resource commitments.

Short-Term Uses Versus Long-Term Productivity

Short-term impacts on plants, animals, and the natural environment may occur as a result of treatments of the National Boll Weevil Cooperative Control Program in central and northern Alabama. However, there should not be any adverse long-term effects because the chemicals recommended by the program do not bioaccumulate, and the program lasts only 3½ years. Increased cotton yields and decreased use of pesticides should be the end result of the proposed program. This result has been demonstrated in previous program areas.

Conflicts With Plans of Federal, State, or Local Agencies

A referendum must be conducted among cotton growers in the proposed expansion area of Alabama. If the referendum passes by at least a 67% positive vote, grower participation in the program becomes mandatory.

As discussed in chapter 2, the National Boll Weevil Cooperative Control Program is a cooperative federal-state-cotton producer program. A regulatory person from the state of Alabama is on the board of directors of the Southeast Boll Weevil Eradication Foundation. Cooperation with state and local agencies is critical to the success of the next program increment in Alabama.

Program personnel will comply with all applicable federal, state, and local environmental laws and regulations in conducting program activities. Specific state and local laws and regulations may include the following:

1. State and local noise ordinances that may restrict the operating hours of pesticide application equipment and vehicles

2. State and local water quality regulations that may establish restrictive buffers around aquatic habitats

3. State and local pesticide applicator certification requirements

4. State and local restrictions on pesticide use, including bans on the application of specific insecticides, the restriction of spraying operations because of weather conditions, the restriction of aerial applications in certain localities (for example, Huntsville city limits), and the establishment of buffers around residences, schools, and other human habitats.

Chapter 5

Conclusions

This chapter discusses the general conclusions reached in the site-specific analysis of the impacts of implementing the National Boll Weevil Cooperative Control Program in Alabama. This discussion analyzes the conclusions in terms of the choice of insecticide for particular locations and circumstances and in terms of the certainty about whether specified impacts would occur.

Choice of Program Insecticide

As with any selection in treatment materials, each of the three insecticides—diflubenzuron, malathion, or methyl parathion—analyzed for boll weevil control in Alabama has its strengths and limitations.

Diflubenzuron

Diflubenzuron, an insect growth regulator, has low toxicities for mammals, fish, birds, honey bees, and most biological control agents. However, it is highly toxic to aquatic invertebrates, such as crayfish. Exposed members of the public and wildlife species are at low risk from its use. Aerial applicators are at low risk, but high doses would put ground applicators at risk.

Diflubenzuron is effective in early season boll weevil treatments, but it must be applied repeatedly and followed by an organophosphate treatment. Diflubenzuron could be used for early-season applications, where aquatic habitats are not present immediately adjacent to the cotton fields.

Malathion

Malathion, an organophosphate, is more toxic to mammals and birds than diflubenzuron, but it is less toxic than the highly toxic methyl parathion. Exposed members of the public and wildlife species are at low risk from its use. Aerial applicators are at low risk, but ground applicators are likely to be at risk from high doses. Malathion is toxic to honey bees, so precautions must be taken to protect commercial hives. Malathion also poses a significant risk to aquatic communities because it is highly toxic to fish species such as bass and bluegills, as well as amphibians and aquatic invertebrates.

Malathion could be used in early-season applications, where aquatic habitats are not present immediately adjacent to cotton fields. Malathion could also be used for mid- or late-season treatments.

Methyl Parathion

Methyl parathion, an organophosphate, is highly toxic to mammals, fish, birds, and honey bees. Although short-term studies in human volunteers have shown it to be no more toxic than malathion at doses of approximately 0.20 to 0.30 mg/kg/day, lifetime studies in rats have shown it to be about 80 times more toxic. The Environmental Protection Agency's (EPA's) Reference Dose (RfD = safe lifetime daily dose) for methyl parathion, based on a rat study, is 0.00025 mg/kg/day, compared to a malathion RfD based on a study in human volunteers of 0.02 mg/kg/day. Exposed members of the public and wildlife species are at risk from its use. Both aerial applicators and ground applicators are at risk. However, methyl parathion is far less toxic to fish and

amphibians than malathion, although it, too, is highly toxic to aquatic invertebrates.

Methyl parathion could be used in locations where particular fish or amphibian species require protection. Where endangered or threatened fish or amphibian species occur in the upper reaches of watersheds, it would afford adequate protection against possible toxic effects from drift or runoff in mid- or late-season treatments. Because cotton growers in Alabama now use methyl parathion routinely to control boll weevils, it would likely find universal acceptance as an alternative to diflubenzuron or malathion. Adequate precautions would have to be taken to prevent direct human or wildlife exposures. Those precautions would include limiting applications in some areas to ground equipment to prevent offsite drift; requiring applicators to operate only in closed, air-conditioned cabs with recirculating air; strictly adhering to protective clothing and laundering requirements; and notifying people near the treated fields.

Mitigation

Two mitigation practices would be the most appropriate and practical for reducing risk to aquatic habitats—using ground equipment near sensitive areas and monitoring local weather. Ground equipment minimizes possible drift onto surface waters, but it does not prevent runoff. Weather monitoring would predict the few large rainstorms during the growing season that could cause significant contaminated runoff into surface waters. These storms should be predicted and treatments suspended at least 24 hours in advance. In northern Alabama most large storms occur in early spring or winter when pesticide treatments are not required.

Program Impacts Certain or Almost Certain To Occur

The program will certainly affect populations of beneficial insects in the cotton fields treated with one of the program insecticides. Other insects and invertebrate species in and on the perimeter of the treated cotton fields will also be affected.

Workers in the program are certain to sustain a number of minor injuries. Major injuries would be infrequent. Fatalities are unlikely. A few workers will have depressed cholinesterase levels from exposure to malathion or methyl parathion. Some are likely to experience at least low-level symptoms, such as headache or nausea. Proper precautions in handling and applying these chemicals and regular cholinesterase testing of program personnel and contract applicators would be critical to limit the possibility that any workers would become symptomatic.

Program Impacts That May Occur

Members of the public may be exposed to one of the program insecticides near treated cotton fields. Some of them may experience depressed cholinesterase levels. One or more may become symptomatic, particularly if exposed to methyl parathion, but no member of the public is expected to have serious acute effects or long-term health effects. Workers routinely involved with diflubenzuron or malathion may be at higher risk of contracting cancer than members of the general population. Ground applicators with repeated exposures to any of the program chemicals may also experience reproductive effects.

Wildlife or aquatic species may be exposed to one of the program insecticides near a treated cotton field. Some individuals may be seriously affected; one or more may die.

Wildlife are at greatest risk from methyl parathion exposure, while fish and amphibian species are at greatest risk from malathion exposure. No significant population effects are expected. There is no reported evidence from the program in the 21 southern counties or the growers in the rest of the state of significant numbers of wildlife or aquatic species dying as a result of malathion or methyl parathion applications to cotton fields.

The state may experience minor economic impacts from the influx of federal program monies, but any major impacts would most likely be confined to small rural communities in which the program would constitute a significant employer. There may be reaction in the grower community and in the general population based on concern about program costs or about the toxicity levels and human and environmental effects of the program insecticides.

Insecticide resistance in the boll weevil and in other cotton pests in Alabama is a potential program effect. The broader scale treatments in the program as opposed to the more isolated treatments now being done by growers in the central and northern parts of the state would subject the pest species to greater pressure to develop that resistance. Insecticide use of at least the proposed intensity in other program areas has not demonstrated this to be an important factor. In addition, the program is expected to be completed in approximately 3½ years, while current practices without the program would be expected to continue indefinitely.

Successful eradication of the boll weevil in Alabama should reduce the overall use of pesticides in cotton production in the state, reduce the amount of pesticides in the environment near the cotton fields, eliminate risks from the longer term use of organophosphates by the growers, and eliminate the early-season loss of beneficial insects and the resulting problems with secondary cotton pests. At that point, an integrated pest management program for the remaining cotton pests would be possible in Alabama.

Minor transitory effects on air quality and noise levels will occur during treatment, but no lasting effects are likely. Some minor damage to plants on or immediately adjacent to treated fields may occur, but no plants are likely to be killed.

Program Impacts Certain or Almost Certain Not To Occur

No impacts are expected to occur to Alabama's geology and topography or to Alabama's climate because the individual cotton fields are approximately 30 acres in size. The combined treated acreage is less than 1% of Alabama's total land surface. None of the physical actions that might affect these elements, such as widespread mining, earth moving, broad-scale use of fire, or risk of wildfires, are in any way part of the program.

Impacts to soils are unlikely to occur. The insecticides are short-lived in the environment and do not seem to affect soil organisms for any significant length of time. The insecticide applications and the machinery used for stalk destruction should not disturb the cotton field soils more than similar agricultural procedures already being used. The program should also have no effect on cultural resources.

Appendix A

Insecticide Fate Modeling and Risk Assessments

Introduction

This appendix describes how the Animal and Plant Health Inspection Service (APHIS) estimated the transport and fate of the program insecticides from their application to various components of the Alabama environment and the risks the components may experience from those exposures. The first section of this appendix discusses the computer models used to estimate airborne insecticide drift that may result if the wind carries the sprayed pesticide offsite. The model also estimates concentrations of pesticides in bodies of water receiving drifted insecticide or insecticide in rainwater running off the cotton fields after a storm. The second section estimates exposure to humans who may be exposed to the insecticides and evaluates the risks of toxic effects from those exposures. The last section estimates exposures that terrestrial wildlife and aquatic species may experience from being near a cotton field during a pesticide application or from being in a body of water that receives drift or runoff insecticide from a rainstorm.

Fate Modeling of Boll Weevil Program Insecticides

When released into the environment, chemical insecticides may enter aquatic systems by three main pathways. Drift from pesticide application equipment may land on neighboring streams and ponds. Runoff from fields may contain insecticide concentrations that enter streams and rivers. Finally, pesticides may leach into the ground with absorbed precipitation and enter groundwater resources. Mathematical models were used to predict the concentration of insecticide entering the aquatic environment in these ways. This analysis required use of the three different models described below.

The AGricultural DISPersion (AGDISP) simulation model is used to model the atmospheric transport of the insecticides as they are released from an aircraft used in the boll weevil program and the deposition of this drift on water surfaces. The Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) model was chosen for its ability to predict the movement and degradation of pesticides in the plant-rooting zone and the migration of insecticides from the field through leaching and surface runoff. Finally, the EXposure Analysis Modeling System (EXAMS) II model was used in this analysis to predict the fate and transport of chemicals in aquatic environments. These models are described in detail in appendix B of volume 1 of the Draft EIS.

All three models require the assumption of a specific insecticide application rate. The application rates used for diflubenzuron, malathion, and methyl parathion were 0.125, 1.17, and 0.5 pounds active ingredient (a.i.) per acre (lb a.i./acre). The properties of the insecticides that determine their behavior in the environment are also an important factor in all three models. A discussion of the environmental fate of the three insecticides considered in this analysis is included in appendix B of volume 1 of the Draft EIS.

Model Simulations

The AGricultural DISPersion Simulation Model

The AGDISP simulation model has been used to predict the drift of insecticides after they are released from application aircraft. A discussion of the assumptions made in the AGDISP simulation about aircraft characteristics, patterns of insecticide deposition, characteristics of pesticide application, and assumptions of meteorological conditions is provided in appendix B of volume 1 of the Draft EIS. Modeling methodology remained the same for this analysis. However, the simulation was rerun for this analysis to ensure that all results were normalized to a 1 lb a.i./acre application rate. The output of the simulation provided information about drift deposition rates as a function of distance from the field. Drift deposition at 25 and 100 feet for each insecticide is provided in table A-1. Regression analysis was performed on data from Ghassemi et al. (1982) to determine the relationship between surface deposition and air concentrations at any distance from a field. The equation was applied to the AGDISP deposition results to obtain insecticide concentrations in the air available for human inhalation. The results of this analysis are also presented in table A-1.

The GLEAMS Model

The GLEAMS model was developed for field-size areas to evaluate the movement and degradation of chemicals within the plant-root zone under various crop management systems. A description of the components of the GLEAMS model itself and the input parameters requirements is included in appendix B of volume 1 of the Draft EIS. Some of the important insecticide parameters used in the GLEAMS modeling are listed in table A-2. The results of this model were manipulated to ascertain water quality effects of the program in headwater streams, farm ponds, and small watersheds. The results of the GLEAMS modeling were also used to determine insecticide mass loadings to the EXAMS II model.

Five representative sites were chosen for modeling, covering the range of soils and topography in Alabama cotton production areas. Although locations, soil types, and other factors may produce somewhat different results, the five scenarios modeled represent a range of typical conditions that, when combined with extreme precipitation patterns, can be expected to show potential for offsite insecticide movement by surface runoff or percolation through soil. The five representative site and soil combinations used were as follows:

- Northern Alabama, Decatur silt loam, flat slopes
- Central Alabama, Savannah loamy sand, flat slopes
- Central Alabama, Savannah loamy sand, steep slopes
- Central Alabama, Bigbee sand, flat slopes
- Central Alabama, Congaree loam, flat slopes

The typical soil types, site characteristics, and cotton management practices were chosen in consultation with research and extension personnel familiar with cotton management in each area. Most cotton in Alabama is grown in silt loam and sandy loam soils, such as Decatur and Savannah types. However, a part of the cotton fields may be in sand or loam soils. The Bigbee and Congaree soil types were examined to determine the fate of insecticides over the

Table A-1. Estimated maximum agricultural drift from aircraft

Applied insecticide	Application rate (lb a.i./acre)	Deposition[a] (mg/m²)		Inhalation[b] (mg/L)	
		25 feet	100 feet	25 feet	100 feet
Diflubenzuron	0.125	1.6	0.6	0.000014	0.0000073
Malathion	1.17	15.2	5.9	0.00011	0.000044
Methyl parathion	0.5	6.5	2.5	0.000048	0.000020

[a]Deposition determined from AGDISP model.
[b]Inhalation determined from regression analysis of deposition and inhalation data from Ghassemi et al., 1982.

Table A-2. GLEAMS chemical parameters

Chemical	Water solubility (ppm)	Half life		K_{oc}	Washoff fraction	Uptake coefficient
		Foliar (Days)	Soil (Days)			
Diflubenzuron	0.2	27	9	6,790	0.05	1
Malathion	145.0	3	3	1,800	0.90	1
Methyl parathion	60.0	3	5	14,000	0.65	1

Note: K_{oc} = organic carbon partition coefficient relates sorption properties to soil organic matter.

range of possible growing conditions. Some of the more important input parameters for each site are listed in table A-3. The typical field size used in the simulations was 30 acres. The Soil Conservation Service runoff curve numbers shown in table A-3 are used to determine the amount of water that runs off from the land surface as a result of a given storm. The numbers were chosen to be realistic, but they represent moderately high runoff conditions.

The rainfall data were obtained for Huntsville and Selma, Alabama, from the National Climatic Data Center, Asheville, North Carolina. These climatic data files cover the periods from January 1, 1985, through September 1, 1988, for Huntsville; and January 1, 1985, through December 31, 1989, for Selma. Precipitation data for Huntsville were used for modeling the northern Alabama soils, and precipitation data for Selma were used for modeling the central Alabama soils. In addition to natural rainfall data, 2-year storm events (that is, for a given location, a storm of a size that occurs on the average only once every 2 years) were added to the precipitation data files to simulate extreme situations. While 2-year storm events in almost all cases produced the greatest pesticide loss from the field, they did not

Table A-3. Site characteristics

Soil type	Saturated conductivity (in 1 hour)	SCS[a] runoff curve number	Soil erodibility	Surface porosity $\left(\frac{C^3}{C^3}\right)$	Surface organic matter (%)	Slope (ft/ft)
Decatur silt loam	0.22	75	0.35	0.43	1.0	0.01
Savannah sandy loam	0.22	78	0.35	0.36	1.5	0.01
Savannah sandy loam	0.22	78	0.35	0.36	1.5	0.05
Bigbee sand	0.35	67	0.15	0.40	1.0	0.01
Congaree loam	0.10	85	0.38	0.40	3.0	0.01

[a]Soil Conservation Service.

Source: USDA, 1984.

necessarily produce the highest runoff concentration, due to smaller runoff volumes from smaller storms. Therefore, runoff from naturally occurring storms was also analyzed and concentrations were used in place of 2-year runoff concentrations when they represented a more extreme situation.

The GLEAMS model requires the user to determine the amount of applied insecticide assumed to be deposited on cotton foliage and the amount assumed to be deposited directly on the soil. This calculation was done based on the age, leaf surface area, and size of the cotton plants. The percentage of applied insecticide deposited on the cotton foliage ranged from 45% to 70%, with the remainder assumed to be deposited directly on the soil.

Two scenarios were evaluated with the GLEAMS model for each pesticide, using naturally occurring rainfall data, augmented with 2-year storm events. For each of the five site and soil combinations described above, the model was run for both a typical and extreme scenario for a field receiving a maximum application rate. For the typical scenario, the assumption was made that the insecticide was being applied on a 7-day interval schedule. For malathion and methyl parathion, a 2-year storm was added in late September, 2 days after the fourth application in the fall diapause schedule. For diflubenzuron, a 2-year storm was added in early July, 2 days after the fourth application in the diflubenzuron schedule. For the extreme scenario, it was assumed that malathion and methyl parathion were applied on a 3-day interval schedule in July or August. A 2-year storm was added to the model 2 days after the third application in a series of applications on this interval. For diflubenzuron, the scenario used for the extreme situation was similar to that used for the typical situation. However, the 2-year storm was assumed to occur 1 day after the fourth application in the diflubenzuron schedule.

The results of GLEAMS were also manipulated to determine the concentration of insecticide in a farm pond following a runoff event. The analysis assumed that the farm pond had a surface area of 1 acre and collected runoff from 33 acres, 30 acres of which were treated cotton fields. The typical scenario was based on a storm occurring 2 days after a spray application during the heaviest application portion of the program. The extreme scenario for the runoff modeling consisted of insecticide application followed by sufficient rain to require a repeat treatment the following day, but not to cause significant runoff. The second application was followed by another storm the next day.

The EXAMS II Model

The simulation of insecticide concentrations for representative river basins was performed with EXAMS II, developed at the Athens Environmental Research Laboratory of the Environmental Protection Agency. EXAMS II is a set of mathematical models that simulate the most important factors that contribute to the degradation and transport of a chemical in an aquatic environment. Additional background on the modeling system is provided in appendix B of volume 1 of the Draft EIS.

The environments selected for modeling (fig. 3-7 in chapter 3) were the Alabama River Basin and the Tennessee

River Basin. The Alabama River Basin was modeled from the Thurlow Dam on the Tallapoosa River downstream to the Claiborne Dam on the Alabama River. The Tennessee River Basin was modeled from the Guntersville Dam to the Wheeler Dam. Determination of main stream length, stream geometries, and streamflow were unaltered from the methodology used in appendix B of volume 1 of the Draft EIS. The physical and chemical parameters used as inputs to EXAMS II are given in table A-4. Pesticide characteristics, model inputs (with the exception of mass loadings), and model operation were also unaltered from the original methodology. Refer to appendix B of volume 1 of the Draft EIS for more detailed discussions of the model use and methodology.

The methodology for determining mass loadings to the compartments in the model remains similar to the procedure described in appendix B of volume 1 of the Draft EIS. However, two loading scenarios for the eradication program were examined in this analysis—a typical scenario and an extreme scenario. No loading scenarios were examined for the suppression alternative. The Tennessee River Basin was modeled assuming that all cotton was grown in relatively flat, silt loamy soils, such as Decatur soils. The Alabama River Basin was modeled assuming that all cotton was grown in relatively flat, loamy sand soils, such as Savannah soils.

The scenarios for diflubenzuron and for malathion and methyl parathion were constructed differently, based on application patterns used for these insecticides. However, for all three insecticides, assumptions were made to facilitate the modeling of realistic typical and maximum situations.

For the typical scenario for diflubenzuron, a 2-year storm was added to the GLEAMS model 2 days after the last diflubenzuron treatment on a 7-day interval cycle. It was also assumed that a maximum of 60 percent of the fields would be treated during any given week. For the maximum scenario for diflubenzuron, an additional assumption was made. It was assumed that on the day of diflubenzuron application, a small storm event (0.5 inches) occurred that did not produce any runoff. The rain did, however, require respraying 20 percent of the fields the following day.

The typical and maximum scenarios for diflubenzuron runoff are based on the fact that there is a small window of opportunity for maximum efficacy and there may be time to respray fields because not all fields will require treatment. In the case of malathion or methyl parathion application, however, all fields in the watershed may require treatment. Therefore, respraying the fields because of washoff 1 day after an application would not be feasible.

Because of these conditions, the typical and maximum scenarios were constructed differently for malathion and methyl parathion. It was assumed that all fields in the watershed would be sprayed over a consecutive 3-day period during the first diapause. It was determined that the maximum pesticide residues would be available for loss from the field following the fourth week of application during the fall diapause period. This was calculated based on the half-lives of the insecticides and the cotton harvesting schedule. For a typical scenario, a 2-year storm was added 2 days after the third consecutive day of treatments (after 100 percent of the fields in the watershed had been

Table A-4. EXAMS II chemical parameters

Chemical	Molecular weight (g/mol)	Vapor pressure (Torr)	Organic carbon fraction K_{oc} (mg/kg/mg/L)	Water solubility (ppm)	Degradation rate constant (units/hour)
Diflubenzuron	311	0.000001	6,790	0.20	0.0204
Malathion	330	0.000125	1,800	145.0	0.00412
Methyl parathion	277	14.4	14,000	50.0	13.7

Note: K_{oc} relates sorption properties to soil organic matter; organic carbon partition coefficient.

sprayed). For a maximum scenario, a 2-year storm was added 1 day after the third consecutive day of treatments. Pesticide loadings to each segment were computed based on cotton grown in the drainage area and the results produced by GLEAMS modeling of the two scenarios described above. The determination of mass loading to each compartment was unchanged from the Draft EIS and the methodology used is described in appendix B of volume 1 of that document.

Surface Water Quality

If surface water resource quality is affected by the program, the effects are expected to be short term. All of the insecticides considered for use in the program degrade rapidly and will quickly disappear from the aquatic environment and soils once the program spraying has been completed. In general, insecticide concentrations will be highest in aquatic environments adjacent to sprayed fields, such as farm ponds and small streams, and decrease with further distance downstream in the watershed. This pattern is caused by increased water volumes available for dilution of the dissolved insecticide, as drainage and rapid degradation of the proposed program insecticides increases.

The GLEAMS model was used to analyze pesticide concentrations in water and soil runoff from a field. This situation represents an extreme condition that is only present until the field runoff enters a live stream or pond. At that point, the concentrations will be reduced as dilution of the insecticide occurs. Tables A-5 and A-6 present the concentrations of insecticide in water and soil runoff coming directly off the field, assuming that a storm occurred 2 days after a heavy pesticide application. Losses of insecticide from leaching are not expected to occur in any soils; therefore, they do not appear on these tables. When the sands were modeled, no significant runoff occurred from any of the large storms. The concentrations of insecticides in runoff water from the sandy loams and silt loams do not vary greatly. The insecticide concentrations in the runoff from the loam soils are generally lower, because of the larger amounts of runoff water from the loam fields.

Several parameters not evaluated in GLEAMS serve to reduce the potential of cotton field runoff reaching surface water. Runoff from agricultural fields is sometimes collected in drainage ditches, especially in areas where water is a scarce commodity and irrigation is used to water crops.

Table A-5. Predicted pesticide losses for 2-year storm: runoff water and eroded soil under the TYPICAL application schedule for the beltwide eradication program[a]

Site/soil	Diflubenzuron		Malathion		Methyl parathion	
	Water (mg/L)	Soil (µg/g)	Water (mg/L)	Soil (µg/g)	Water (mg/L)	Soil (µg/g)
Decatur silt loam (1% slopes)	0.0194	1.3119	0.3391	6.1217	0.0570	8.0003
Savannah sandy loam (1% slopes)	0.0137	2.2835	0.2107	9.3384	0.0316	10.8812
Savannah sandy loam (5% slopes)	0.0137	2.3608	0.2107	9.6587	0.0385	13.7157
Bigbee sand (1% slopes)	0.0172	7.0503	0.1750	18.9977	0.0529	44.6418
Congaree loam (1% slopes)	0.0089	2.4111	0.1895	13.5807	0.0218	12.1465

[a]This scenario assumes that pesticides are being applied on a 7-day interval and that a 2-year storm occurs 2 days after a pesticide application. For diflubenzuron, the model storm occurs in early July; for malathion and methyl parathion, the model storm occurs in early October during the fourth week of diapause treatments.

Table A-6. Predicted pesticide losses for model storm: runoff water and eroded soil under the MAXIMUM application schedule for the beltwide eradication program[a]

Site/soil	Diflubenzuron		Malathion		Methyl parathion	
	Water (mg/L)	Soil (µg/g)	Water (mg/L)	Soil (µg/g)	Water (mg/L)	Soil (µg/g)
Decatur silt loam (1% slopes)	0.0208	1.3938	0.3904	6.9984	0.0617	8.6021
Savannah sandy loam (1% slopes)	0.0149	2.4854	0.4129	18.0751	0.0662	22.5225
Savannah sandy loam (5% slopes)	0.0149	2.5693	0.4129	18.7575	0.0662	23.3727
Bigbee sand (1% slopes)	0.0187	7.6588	0.3327	36.0866	0.0902	76.1184
Congaree loam (1% slopes)	0.0097	2.6336	0.3740	26.7225	0.0374	20.8025

Note: For diflubenzuron, this scenario assumes that the pesticide is being applied at 7-day intervals and that a 2-year storm occurs 1 day after the fourth application, which occurs in early July.

[a]For malathion and methyl parathion, this scenario assumes that pesticides are being applied on a 3-day interval and that a 2-year storm occurs 2 days after a pesticide application during late summer.

Fallow vegetation around cotton fields also tends to prevent insecticide-laden runoff from reaching surface water. The vegetation retains runoff sediment and adsorbs some insecticides in solution.

A farm pond scenario was also examined in this analysis. This scenario was considered important because of the farm pond's proximity to spraying operations and its accessibility to human, wildlife, and domestic animal populations. Because the surface area of a pond is large compared to the surface area of drainage ditches and streams, the effects of drift and runoff on farm pond water quality were examined. Table A-7 presents the results of computations based on drift from a field with a buffer (from the pond edge to the cotton field edge) of 100 feet, drift from a field with a buffer of 25 feet, runoff from a field, and a direct spray of the pond surface. The direct spray scenario assumed that a single swath was flown across the pond surface and that all pesticide drift from the swath landed in the pond. The concentrations determined in both runoff scenarios were below those present in direct runoff from a field, because of the dilution of the runoff by the pond water.

The field runoff and farm pond scenarios represent the areas where the greatest concentrations of insecticides in the aquatic environment are expected. The larger rivers represent areas where the concentrations of insecticides will be significantly lower. Lower concentrations are expected because of the greater volume of water available for dilution and degradation of insecticides over time. The EXAMS II modeling estimated the riverine concentration of insecticides under the proposed eradication programs for typical and extreme scenarios. Since the GLEAMS model predicted no leaching and thus no groundwater transport of insecticides from treated cotton fields, the only portion of insecticide contributed in EXAMS II was from surface water flow. Tables A-8 and A-9 illustrate the maximum predicted river concentrations in any compartment after 7 days of the modeled storm for the two river basins modeled. Because a steady-state loading of the insecticides was assumed, the highest concentrations are found on day 7 of the precipitation event. Maximum insecticide concentrations in the modeled rivers were several orders of magnitude lower than maximum insecticide concentrations leaving the cotton fields.

The peak concentrations presented in tables A-8 and A-9 are representative of only part of the modeled river. Dissolved concentrations of methyl parathion and diflubenzuron in the Alabama River peaked just upstream of Montgomery and steadily declined to less than 5% of the peak at the

Table A-7. Farm pond water concentrations for several scenarios for the beltwide eradication program

Scenario	Diflubenzuron (mg/L)	Malathion (mg/L)	Methyl parathion (mg/L)
Direct spray	0.00929	0.0870	0.0372
Extreme runoff	0.00483	0.168	0.0306
Typical runoff	0.00261	0.0455	0.00946
Drift onto pond with a 25-foot buffer	0.00123	0.0115	0.00492
Drift onto pond with a 100-foot buffer	0.000741	0.00693	0.00296

Table A-8. Maximum predicted insecticide concentrations in the ALABAMA RIVER 7 days after a model storm under the typical and maximum scenarios for the beltwide eradication program

Element	Typical scenario			Maximum scenario		
	Diflubenzuron	Malathion	Methyl parathion	Diflubenzuron	Malathion	Methyl parathion
Water:						
Total (mg/L)	0.00000326	0.00168	0.000263	0.00000503	0.00206	0.000307
Dissolved (mg/L)	0.00000324	0.00167	0.000262	0.00000501	0.00206	0.000306
Sediments (mg/kg)	0.000110	0.0151	0.0183	0.000170	0.0186	0.0214
Biota (mg/g)	0.00949	1.47	0.0973	0.0147	1.81	0.114
Sediments:						
Total (mg/L)	0.00000824	0.00234	0.00395	0.0000127	0.00288	0.00462
Dissolved (mg/L)	0.000000225	0.000231	0.0000558	0.000000348	0.000284	0.0000652
Sediments (mg/kg)	0.00000764	0.00207	0.00391	0.0000118	0.00255	0.00457
Biota (mg/g)	0.000659	0.202	0.0208	0.00102	0.249	0.0242

Table A-9. Maximum period insecticide concentrations in the TENNESSEE RIVER 7 days after a model storm under the typical and maximum scenarios for the beltwide eradication program

Element	Typical scenario			Maximum scenario		
	Diflubenzuron	Malathion	Methyl parathion	Diflubenzuron	Malathion	Methyl parathion
Water:						
Total (mg/L)						
Dissolved (mg/L)	0.00000126	0.000358	0.0000586	0.00000150	0.000401	0.0000668
Sediments (mg/kg)	0.000000126	0.000358	0.0000584	0.00000149	0.000400	0.0000665
Biota (mg/g)	0.000426	0.00322	0.00409	0.000507	0.00360	0.00466
	0.0367	0.314	0.0217	0.0437	0.351	0.0247
Sediments:						
Total (mg/L)	0.0000320	0.000573	0.000884	0.0000381	0.000640	0.00101
Dissolved (mg/L)	0.000000875	0.0000564	0.0000125	0.00000104	0.0000631	0.0000142
Sediments (mg/kg)	0.0000297	0.000508	0.000874	0.0000353	0.000568	0.000996
Biota (mg/g)	0.00256	0.0495	0.00464	0.00304	0.0554	0.00528

Claiborne Dam, the downstream end of the study segment (see fig. 3-8). Dissolved levels of malathion were within 10% of the maximum concentration from Montgomery downstream to the southern boundary of Dallas County. This segment of the river corresponds to the highest cotton production areas in the watershed. At the downstream end of the modeled segment, however, malathion concentrations are less than 50% of the peak. In the Tennessee River Basin, concentrations of all three insecticides peaked near Huntsville, which corresponds to the only section of the modeled segment that is not part of a reservoir. Concentrations of all insecticides drop sharply as the river enters Wheeler Reservoir. Concentrations were elevated again just upstream of the Wheeler Dam as the Elk River enters the reservoir. However, the concentrations in this second peak for malathion, methyl parathion, and diflubenzuron are 50%, 20%, and 30% of the upstream peak concentrations. Concentrations drop off sharply for all three insecticides at Wheeler Dam, the downstream end of the study segment.

This analysis examined insecticide concentrations from the environments where the highest concentrations would be expected—direct field runoff and farm ponds—to environments where much lower concentrations would be expected—rivers and reservoirs. Aquatic environments downstream of cotton production fields will exhibit insecticide concentrations below those found in aquatic environments adjacent to fields. It would be misleading to derive numbers for these situations because so many variables affect insecticide concentrations on a site-by-site basis. However, it is reasonable to assume that the variables in these situations will produce a range of insecticide concentrations, ranging from undiluted field runoff down to negligible levels, depending on the specific site and upstream conditions.

Results from the GLEAMS modeling were also used to examine potential residues of the insecticides that remain in the field soil. The results of this analysis indicate that for all insecticides and all representative soil types, no cumulative buildup of residues in the soil is expected. In each year of the program, the maximum buildup of residues occurs at the end of the maximum application period and decreases rapidly. While Bigbee sand exhibited residual pesticide longer than the other soils, no insecticide was present in any soils when the next application year began.

Groundwater Quality

The GLEAMS model output provided information on the potential of insecticides to leach below the root zone and possibly into the groundwater. The rooting depth for cotton was assumed to be 40 inches (100 cm). Leaching potentials of diflubenzuron, malathion, and methyl parathion were evaluated at all five representative sites. The modeling results indicate that percolation through the soil (even during extreme storm events) is negligible and no pesticide percolated through the root zone.

Tables A-10 and A-11 illustrate the distribution of leached insecticide residues in Decatur silt loam and Savannah sandy loam after a 2-year storm during the heaviest application period for typical and maximum application scenarios. None of the insecticides reached a depth of more than 20 inches (50 cm) in the Decatur silt loam and Savannah sandy loam

Table A-10. Pesticide concentration (in parts per million) in DECATUR SILT LOAM after a 2-year storm during the maximum application period

Northern Alabama	Depth of soil (cm)				
	0-1	1-16	16-33	33-50	50-67
Average scenario used in GLEAMS model:					
Diflubenzuron	0.6281	0.0105	0.0000	0.0000	0.0000
Malathion	5.4191	0.4963	0.0162	0.0004	0.0000
Methyl parathion	3.2383	0.0267	0.0000	0.0000	0.0000
Maximum scenario used in GLEAMS model:					
Diflubenzuron	0.6693	0.0121	0.0001	0.0000	0.0000
Malathion	6.1423	0.4134	0.0074	0.0000	0.0000
Methyl parathion	3.4805	0.0218	0.0001	0.0000	0.0000

Table A-11. Pesticide concentration (in parts per million) in SAVANNAH SANDY LOAM after a 2-year storm during the maximum application period

Central Alabama	Depth of soil (cm)				
	0-1	1-16	16-33	33-50	50-67
Average scenario used in GLEAMS model:					
Diflubenzuron	0.5870	0.0068	0.0000	0.0000	0.0000
Malathion	3.8223	0.1514	0.0023	0.0000	0.0000
Methyl parathion	2.4874	0.0103	0.0000	0.0000	0.0000
Maximum scenario used in GLEAMS model:					
Diflubenzuron	0.6390	0.0076	0.0000	0.0000	0.0000
Malathion	7.4650	0.3203	0.0048	0.0000	0.0000
Methyl parathion	5.2094	0.0238	0.0000	0.0000	0.0000

soils. The insecticide leaching in Bigbee sand was also examined. Although a small quantity of malathion may leach to a 20-inch depth (50 cm) in these sands, no malathion leached below the root zone. In all soils studied, malathion accumulated to the highest concentration in soils and migrated farthest downward although it never reached the groundwater in significant quantities. As discussed previously, all of the insecticides readily degrade. They also are readily adsorbed to the soil. Based on these two processes and on the results of the GLEAMS modeling, none of the insecticides should reach the groundwater in any significant amount.

The Alabama Department of Environmental Management and the Alabama Department of Agriculture and Industries are conducting a groundwater monitoring study, the results of which will be used in developing a groundwater protection strategy for pesticide use in Alabama. The monitoring for Phase I of this study was completed in 1989. This phase sampled 50 private wells in 10 counties to determine occurrences of pesticides in groundwater. Each well was

sampled in early May, late June or early July, and mid-August. In the 150 samples taken, only 1 sample contained a detectable concentration of malathion of 0.09 parts per billion (ppb). This well was located in Colbert County. No diflubenzuron or methyl parathion was detected in any samples. Phase II of this program is currently sampling additional wells in each county sampled in Phase I. An additional phase of the study may involve the installation of monitoring wells adjacent to cotton fields for a more complete picture of pesticide fate.

Human Exposure and Risk Assessment

This section summarizes the human health risk assessment of potential adverse effects to workers or members of the public that may result from using the insecticides malathion, diflubenzuron, and methyl parathion in the boll weevil control program in Alabama. Detailed information on laboratory toxicity studies, environmental fate and transport modeling methodology, and exposure analysis methodology is available in appendix B of volume 1 of the Draft EIS.

The risk assessment consists of four parts: (1) a hazard analysis that examines the toxic effects of each chemical in humans and laboratory animals to determine toxicity reference levels; (2) a model of the environmental fate and transport to determine the levels of insecticide residue that may be present in various elements of the environment; (3) an exposure analysis, in which insecticide doses from several scenarios to workers and members of the public are estimated; and (4) a risk analysis, in which the toxicity reference levels are compared to the dose estimates. This allows the characterization of potential risks to individuals that may be exposed to the insecticides as a result of the boll weevil control program in Alabama.

Refer to volume 1 of the Draft EIS for the National Boll Weevil Cooperative Control Program for information on the toxicity and environmental fate of the insecticides, qualitative discussions of the risk of mutagenic effects, and information on the risks to sensitive individuals.

Hazard Analysis

The toxicity reference levels used in this risk analysis are summarized in table A-12. Based on a review of the toxicity of the insecticides, no-observed-effect levels (NOELs) were determined for each compound for general systemic, reproductive, and developmental health effects. NOELs are doses, in milligrams of chemical per kilogram of body weight per day (mg/kg/day), at which no adverse effects are observed in laboratory studies. In the studies in which NOELs were determined, adverse effects were present at the next highest dose level, with the exception of the study on which the reproductive NOEL for diflubenzuron is based. No effects were noted at the highest dose tested in this study. Therefore, the true threshold for reproductive effects from diflubenzuron may be much greater than the NOEL used in this analysis. The systemic and reproductive NOELs used in this risk assessment are summarized in table A-12.

For the insecticides that have given any indication in laboratory studies of potential carcinogenicity (malathion and diflubenzuron), cancer potency factors were identified. These factors represent the probability, averaged over a lifetime, that a tumor will result from exposure to one mg/kg/day of the compound. Cancer potency factors are

Table A-12. Toxicity levels used in this analysis

Insecticide	Systemic NOEL (mg/kg/day)	Reproductive NOEL (mg/kg/day)	Cancer potency $(mg/kg/day)^{1}$
Malathion	0.23	25.0	0.00376
Diflubenzuron	1.0	>8.0	0.01718[a]
Methyl parathion	0.025	0.025	NA[b]

[a]The carcinogenicity information on diflubenzuron is inconclusive; however, because positive results were obtained in one study, a cancer risk analysis was conducted.
[b]NA = Not applicable.

presented in units of probability per mg/kg/day, or $(mg/kg/day)^{-1}$ and are summarized in table A-12. Although these compounds are not necessarily proven carcinogens, the conservative nature of this risk assessment makes a cancer risk analysis appropriate for insecticides where a positive response has been noted.

Environmental Fate and Transport

In this risk analysis, the computer simulation AGDISP was used to predict the drift of insecticides after release from the application aircraft. This simulation takes into account the application rate, aircraft and spray system characteristics, formulation, meteorology, release height, canopy characteristics, and topography. Regression analysis was performed on data from Ghassemi et al. (1982) to determine the relationship between surface deposition and air concentrations at any distance from a field. The equation was applied to the AGDISP deposition results to obtain insecticide concentrations in the air available for human inhalation. The results of the simulation and regression analysis are incorporated into the exposure analysis. These estimates of surface deposition and airborne concentrations are used to calculate doses for members of the public and workers who may have dermal or inhalation exposure to airborne spray drift, dermal exposure to vegetation with drift residues, or ingestion exposure from contaminated water or food items containing drift residues.

Runoff from treated fields was also evaluated, using the computer model GLEAMS to estimate the concentrations of pesticides in water flowing off a field. The scenario for the runoff modeling consisted of insecticide application, followed by only enough rain to require a repeat treatment the following day but not enough to cause significant runoff. The second application was followed by a storm that generated the maximum runoff insecticide concentration seen in the model. Resulting water concentrations in the ponds receiving runoff were incorporated into the risk analysis as extreme doses.

Exposure Analysis

The application rates of the insecticides proposed for use in the Alabama boll weevil control program are summarized in table A-13.

There are several categories of workers in the Alabama program. Pilots fly the planes during aerial applications

Table A-13. Chemical treatment application rates

Insecticide	Application rate (lb a.i./acre)
Malathion	1.17
Diflubenzuron	0.125
Methyl parathion	0.50

of insecticide. Mixer/loaders load insecticide into the plane's tank by connecting a hose from the storage tank to the plane's tank; a single mixer/loader would do this approximately three times per day. No flaggers are involved in aerial insecticide applications in Alabama. However, one worker acts as a combined observer and environmental evaluator who sets out dye cards to evaluate drift, observes the aerial application, and later collects the dye cards. Ground-based insecticide applications are conducted using either a hiboy tractor with a boom or a mist blower.

The hiboy operator and assistant refill the equipment approximately three times per day while the mist blower operator refills the mist blower every four days. The hours per day and days per year worked by workers in each category are summarized in table A-14.

Members of the public may also be exposed to the boll weevil control insecticides. This may happen through dermal or inhalation exposure to insecticide spray drift or consumption of water or food items that are contaminated with insecticide residues.

Accidental exposures may affect workers or members of the public. These include actions such as an accidental spill of insecticide onto the skin, immediate reentry to a treated area, direct spray of a person, accidental release of insecticide into drinking water, or direct spray of food items that are later consumed.

Estimated typical, extreme, and accidental doses to workers and members of the public are summarized in tables A-15, A-16, and A-17 for exposures to malathion, diflubenzuron, and methyl parathion.

Risk Analysis

Estimation of Systemic and Reproductive Risks

To quantify the risks of general systemic and reproductive/developmental health effects, estimated doses were compared to laboratory NOELs. The ratio between the NOEL and the estimated human dose is called the margin of safety (MOS). For example, a NOEL of 20 mg/kg/day divided by a dose of 0.2 mg/kg/day results in an MOS of 100. This margin of safety approach is used to compensate for the inherent uncertainty in extrapolating a dose-response relationship from studies in laboratory animals to human health risks and to allow for the variation in sensitivity among the human population. A factor of 10 is allowed for each of these uncertainties, resulting in an MOS of 10 x 10, or 100, that is recognized as unlikely to result in adverse effects in humans. For the insecticide malathion, the systemic NOEL is based on a study in humans; in this case, an MOS of 10 is considered sufficiently protective of human

Table A-14. Insecticide application workers and exposure times

Worker	Hours per day		Days per year	
	Typical	Extreme	Malathion and methyl parathion	Diflubenzuron
Pilot	6	10	140	25
Aerial mixer/loader	0.75	2	140	25
Observer/environmental evaluation crew:				
Year 1	8	12	140	25
Year 2	8	12	70	12
Year 3	8	12	28	5
Ground equipment operators:				
Hiboy operator:				
Applying				
Year 1	6	10	140	25
Year 2	6	10	70	13
Year 3	6	10	70	13
Mixing/loading				
Year 1	0.5	1	140	25
Year 2	0.5	1	70	13
Year 3	0.5	1	70	13
Mist blower operator:				
Applying				
Year 1	8	12	140	25
Year 2	8	12	70	12
Year 3	8	12	28	5
Mixing/loading				
Year 1	0.2	0.2	56	10
Year 2	0.2	0.2	28	5
Year 3	0.2	0.2	7	3

health. For the insecticide diflubenzuron, a true reproductive NOEL has not been determined because no effects were observed at the highest dose tested in any reproductive or developmental toxicity study using that insecticide. Therefore, the reproductive risk assessment for diflubenzuron may be overly conservative in estimating risks.

As the estimated dose to humans approaches the NOEL, the risk to humans increases. In this risk assessment when an estimated dose exceeds a NOEL, the ratio is reversed (that is, the dose is divided by the NOEL) and preceded by a minus sign to indicate the factor by which the dose exceeds the NOEL. An MOS of -10, for example, indicates that the dose is 10 times higher than the laboratory-determined NOEL. If the dose equals the NOEL, there is a margin of safety of 0.

Although margins of safety less than 100 (or, in the case of systemic risks from malathion, 10) are considered to present a risk of toxic effects, it should be noted that MOSs are based on a comparison with doses that produced no effects in laboratory animals. All NOELs used in this risk analysis

Table A-15. Control program exposures to MALATHION

Exposure scenario	Dose (mg/kg/day)	
	Typical	Extreme
Public[a]:		
Dermal and inhalation:		
Drift	0.00141	0.00477
Dietary:		
Water	0.00000787	0.0000193
Fish	0.0000728	0.000178
Venison	0.0000134	0.000150
Legumes	0.00119	0.00310
Berries	0.000597	0.00155
Workers[b]:		
Pilot	0.00326	0.00783
Aerial mixer/loader	0.000900	0.00471
Observer/environmental evaluation team	0.00556	0.0394
Hiboy operator	0.100	0.886
Mist blower operator	0.120	0.241
Accidents:		
Spill of concentrate		240.0
Broken hose		240.0
Immediate field reentry		0.000469
Direct spray—adult		0.0285
Drinking reservoir water/release		0.0744
Eating berries—direct spray		0.0134
Eating legumes—direct spray		0.0267

[a]Public exposures: typical at 100 feet, extreme at 25 feet.
[b]Worker exposures: typical is based on average dose, extreme is based on upper 95% confidence level.

are based on subchronic or chronic repeated exposures and are compared to doses that were calculated on a realistic basis, resulting in up to 140 daily exposures per year for workers or up to 10 daily exposures per year for members of the public. Comparing daily chronic NOELs to doses received on a less frequent basis may tend to overestimate the risks, especially those resulting from one-time exposures, such as accidents.

For all chemicals except malathion, exposures resulting in MOSs equal to or greater than 100 are assumed to present a negligible risk to human health. If the MOS is between 10 and 100, this is described as a moderate risk. If the MOS is less than 10, it is assumed that there is a significant potential for adverse health effects. In the case of systemic risks from malathion, MOSs equal to or greater than 10 are termed negligible, MOSs between 0 and 10 are described as presenting moderate risks, and MOSs less than 0 pose significant risks.

MOSs for risks to members of the public and workers from typical and extreme exposures are summarized in tables A-18 and A-19, respectively.

Table A-16. Control program exposures to DIFLUBENZURON

Exposure scenario	Dose (mg/kg/day)	
	Typical	Extreme
Public[a]:		
Dermal and inhalation		
Drift	0.000190	0.000477
Dietary		
Water	0.000000226	0.0000000576
Fish	0.00000566	0.00000144
Venison	0.00000141	0.0000160
Legumes	0.000129	0.000333
Berries	0.0000643	0.000166
Workers[b]:		
Pilot	0.000421	0.00101
Aerial mixer/loader	0.000117	0.000612
Observer/environmental evaluation team	0.00147	0.00322
Hiboy operator	0.121	1.08
Mist blower operator	0.110	0.239
Accidents:		
Spill of concentrate		66.2
Broken hose		16.5
Immediate field reentry		0.000572
Direct spray—adult		0.00372
Drinking reservoir water/release		0.00418
Eating berries—direct spray		0.00143
Eating legumes—direct spray		0.00286

[a]Public exposures: typical at 100 feet, extreme at 25 feet.
[b]Worker exposures: typical is based on average dose, extreme is based on upper 95% confidence level.

Estimation of Cancer Risks

A cancer risk analysis was conducted for malathion and diflubenzuron, based on the results of laboratory studies that suggest these insecticides may have the potential to cause cancer. Although the evidence is inconclusive in the case of diflubenzuron, a cancer risk analysis was appropriate in consideration of the conservative nature of this risk assessment. Methyl parathion does not appear to be carcinogenic based on laboratory animal study data.

The risk of cancer was calculated for an individual by averaging the estimated cumulative lifetime dose from the Alabama boll weevil control program over a 70-year life span and multiplying the result by the cancer potency factor for the insecticide. This calculation resulted in an estimated probability that cancer will occur at some point in the person's life as a result of the assumed exposures. In all cases, the duration of the control program in Alabama was assumed to be 3 years. The calculation of the lifetime dose to members of the public included the assumption that typical doses are received nine times per year and extreme doses are received once per year. Calculation of lifetime doses to workers incorporated the assumption that the worker receives a typical dose 90% of the time and an extreme dose 10% of the time.

Table A-17. Control program exposures to METHYL PARATHION

Exposure scenario	Dose (mg/kg/day)	
	Typical	Extreme
Public[a]:		
Dermal and inhalation		
Drift	0.000727	0.00187
Dietary		
Water	0.00000143	0.000000231
Fish	0.0000312	0.00000502
Venison	0.00000561	0.0000639
Legumes	0.000510	0.00133
Berries	0.000255	0.000663
Workers[b]:		
Pilot	0.00168	0.00405
Aerial mixer/loader	0.000466	0.00245
Observer/environmental evaluation team	0.00326	0.0152
Hiboy operator	0.122	1.08
Mist blower operator	0.123	0.259
Accidents:		
Spill of concentrate		63.3
Broken hose		31.7
Immediate field reentry		0.000572
Direct spray—adult		0.0149
Drinking reservoir water/release		0.00800
Eating berries—direct spray		0.00571
Eating legumes—direct spray		0.0114

[a]Public exposures: typical at 100 feet, extreme at 25 feet.
[b]Worker exposures: typical is based on average dose, extreme is based on upper 95% confidence level.

Cancer risks of 1 in 1 million (1×10^{-6}) are considered to be acceptable risks, as they are generally thought to represent a negligible increase over the background cancer risk of approximately 1 in 4 that is present in the United States. One in 1 million is also commonly used by EPA as a point of departure in cancer risk analyses.

Cancer risks to members of the public and workers as a result of the boll weevil program in Alabama are summarized in table A-20.

Risks of Systemic and Reproductive Health Effects

Margins of safety for systemic and reproductive risks from typical, extreme, and accidental exposures to members of the public and workers are presented in tables A-21 through A-23. Moderate and significant risks are discussed in the following sections.

Risks to Members of the Public—Typical Exposures. Typical exposures of the public to malathion and diflubenzuron result in negligible systemic and reproductive effects. Methyl parathion presents moderate risks of systemic effects as a result of dermal and inhalation exposure to spray drift at 100 feet from a treated area and from consuming berries or legumes with drift residues 100 feet from a treated area. Reproductive risks to the public from typical exposures to methyl parathion are negligible.

Table A-18. Summary of risks to the public and workers from TYPICAL exposures in the Boll Weevil Cooperative Control Program in Alabama

Insecticide	MOSs for systemic effects	MOSs for reproductive effects
Malathion	All MOSs greater than 10 for the public.	All MOSs greater than 100 for the public.
	MOSs less than 10 for hiboy and mist blower operators.	All MOSs greater than 100 for workers.
Diflubenzuron[a]	All MOSs greater than 100 for the public.	All MOSs greater than 100 for the public.
	MOSs less than 10 for hiboy and mist blower operators.	MOSs less than 100 for hiboy and mist blower operators.
Methyl parathion	MOSs less than 100 for dermal and inhalation exposure to spray drift and consumption of legumes or berries with drift residues.	All MOSs greater than 100 for the public.
	MOSs less than 100 for pilot and mixer/loader. MOS less than 10 for observer/ environmental evaluation team. Doses exceed NOEL for hiboy and mist blower operators.	MOS less than 100 for observer/environmental evaluation team. MOSs less than 10 for hiboy and mist blower operators.

Note: MOSs greater than 100 (greater than 10 for systemic risks from malathion) are considered acceptable levels of risk.

[a]For reproductive MOSs from diflubenzuron, an MOS less than 100 may not necessarily indicate a risk of adverse effects, because the NOEL used in this analysis was the highest dose tested in any diflubenzuron reproductive toxicity study.

Risks to Members of the Public—Extreme Exposures. Systemic and reproductive risks to the public from extreme exposures to malathion and diflubenzuron are negligible. Methyl parathion poses moderate risks of systemic effects as a result of dermal and inhalation exposure to spray drift at 25 feet from a treated area and as a result of consuming legumes or berries with drift residues 25 feet from a treated area.

Risks to Members of the Public—Accidental Exposures. Accident scenarios for members of the public include direct exposure of an adult to aerial spray, consumption of legumes or berries that have been directly sprayed, and consumption of water from a reservoir that received an 80-gallon accidental spill of insecticide from an aircraft.

For malathion, there are moderate risks of systemic effects as a result of a direct spray, drinking 2 liters of water from a reservoir containing an accidental release of 80 gallons of malathion, and from eating legumes that were directly sprayed. Risks of reproductive effects from malathion to the public from all accident scenarios are negligible.

Table A-19. **Summary of risks to the public and workers from EXTREME exposures in the Boll Weevil Cooperative Control Program in Alabama**

Insecticide	MOSs for systemic effects	MOSs for reproductive effects
Malathion	All MOSs greater than 10 for the public.	All MOSs greater than 100.
	MOS less than 10 for observer/environmental evaluation team. Dose equals NOEL for mist blower operator. Dose exceeds NOEL for hiboy operator.	MOS less than 100 for hiboy operator.
Diflubenzuron[a]	All MOSs greater than 100 for the public.	All MOSs greater than 100 for the public.
	MOS less than 10 for mist blower operator. Dose exceeds NOEL for hiboy operator.	MOS less than 100 for mist blower operator. MOS less than 10 for hiboy operator.
Methyl parathion	MOSs less than 100 for consumption of legumes or berries with drift residues and for dermal and inhalation exposure to drift.	All MOSs greater than 100 for the public.
	MOS less than 100 for mixer/loaders. MOSs less than 10 for pilots and observer/environmental evaluation team. Dose exceeds NOEL for hiboy and mist blower operators.	MOS less than 100 for pilots and observer/environmental evaluation team. Dose equals NOEL for mist blower operator. Dose exceeds NOEL for hiboy operator.

Note: MOSs greater than 100 (greater than 10 for systemic risks from malathion) are considered acceptable levels of risk.

[a]For reproductive MOSs from diflubenzuron, an MOS less than 100 may not necessarily indicate a risk of adverse effects, because the NOEL used in this analysis was the highest dose tested in any diflubenzuron reproductive toxicity study.

For diflubenzuron, risks of systemic or reproductive effects as a result of these accidents are negligible.

For methyl parathion, there are significant risks of systemic effects and moderate risks of reproductive effects from being directly sprayed by the insecticide, from drinking reservoir water contaminated by a release, and from eating berries or legumes that were directly sprayed.

Risks to Workers—Typical Exposures. There are moderate risks of systemic effects from typical exposures to malathion for hiboy and mist blower operators. Reproductive risks to workers as a result of typical exposures to malathion are negligible.

Table A-20. **Summary of cancer risks to the public and workers from the Boll Weevil Cooperative Control Program in Alabama**

Insecticide	Risks to the public	Risks to workers
Malathion	Less than 1 in 1 million for all members of the public.	Seven in 1 million for hiboy operators and 5 in 1 million for mist blower operators.
Diflubenzuron[a]	Less than 1 in 1 million for all members of the public.	Seven in 1 million for hiboy operators and 4 in 1 million for mist blower operators.
Methyl parathion	There are insufficient toxicological data to assess the carcinogenicity of methyl parathion.	There are insufficient toxicological data to assess the carcinogenicity of methyl parathion.

Note: Cancer probabilities greater than 1 in 1 million are considered to present an unacceptable level of risk.

[a]The carcinogenicity information on diflubenzuron is inconclusive. However, because positive results were obtained in one study, a cancer risk analysis was conducted.

There are significant risks of systemic effects and moderate risks of reproductive effects from typical exposures to diflubenzuron for hiboy and mist blower operators.

For typical exposures to methyl parathion, there are moderate risks of systemic effects to pilots and mixer/loaders and significant risks of systemic effects to observer/environmental evaluation workers, hiboy operators, and mist blower operators. There is a moderate risk of reproductive effects to observer/environmental evaluation workers and significant risks of reproductive effects to hiboy and mist blower operators.

Risks to Workers—Extreme Exposures. There is a moderate risk of systemic effects to observer/environmental evaluation workers and significant risks of systemic effects to hiboy and mist blower operators from extreme exposures to malathion. There is also a moderate risk of reproductive effects for hiboy operators.

Extreme exposures to diflubenzuron pose significant systemic risks to hiboy and mist blower operators, a significant reproductive risk to hiboy operators, and a moderate reproductive risk to mist blower operators.

Methyl parathion presents moderate risks of systemic effects to mixer/loaders from extreme exposures and of reproductive effects to pilots and observer/environmental evaluation workers. There are significant systemic risks to pilots, observer/environmental evaluation workers, and hiboy and mist blower operators, and significant reproductive risks to hiboy and mist blower operators.

Risks to Workers—Accidental Exposures. Accident scenarios for workers include dermal exposure from a spill of concentrate, dermal exposure from the spray from a broken hose while loading aircraft, and immediate reentry into a treated area.

Table A-21. Control program margins of safety for MALATHION

Exposure scenario	Systemic Typical	Systemic Extreme	Reproductive Typical	Reproductive Extreme
Public[a]:				
Dermal and inhalation:				
Drift	163	63	10,000	6,868
Dietary:				
Water	10,000	10,000	10,000	10,000
Fish	3,158	1,289	10,000	10,000
Venison	10,000	1,533	10,000	10,000
Legumes	193	74	10,000	8,059
Berries	385	148	10,000	10,000
Workers[b]:				
Pilot	71	29	7,666	3,194
Aerial mixer/loader	256	49	10,000	5,304
Observer/environmental evaluation team	41	6	4,498	635
Hiboy operator	2	-4	250	28
Mist blower operator	2	0	208	104
Accidents:				
Spill of concentrate		-1,050		-10
Broken hose		-1,050		-10
Immediate field reentry		490		10,000
Direct spray—adult		8		877
Drinking reservoir water/release		3		336
Eating berries—direct spray		17		1,870
Eating legumes—direct spray		9		935

Note: MOSs greater than 10,000 are listed as 10,000. MOSs are based on a systemic NOEL of 0.23 and a reproductive NOEL of 25.

[a]Public exposures: typical at 100 feet, extreme at 25 feet.
[b]Worker exposures: typical is based on average dose, extreme is based on upper 95% confidence level.

Malathion, diflubenzuron, and methyl parathion present significant systemic and reproductive risks from a spill of concentrate on the skin or spray from a broken hose. Additionally, methyl parathion poses a moderate risk of systemic effects from immediate reentry into a treated area.

Cancer Risks

Cancer risk estimates to workers and members of the public as a result of exposure to malathion or diflubenzuron are presented in table A-24; risks greater than 1 in 1 million are discussed in the following paragraphs.

Cancer risks to members of the public are less than 1 in 1 million for all exposures from malathion or diflubenzuron under typical, extreme, and accidental exposure scenarios. Therefore, negligible cancer risks to the public are expected to result from public exposure to these insecticides as a result of the boll weevil control program in Alabama.

There could be significant cancer risks from malathion for hiboy and mist blower operators, of 7.33 in 1 million and

Table A-22. Control program margins of safety for DIFLUBENZURON

Exposure scenario	Systemic		Reproductive	
	Typical	Extreme	Typical	Extreme
Public[a]:				
Dermal and inhalation:				
Drift	5,263	2,096	10,000	10,000
Dietary:				
Water	10,000	10,000	10,000	10,000
Fish	10,000	10,000	10,000	10,000
Venison	10,000	10,000	10,000	10,000
Legumes	7,778	3,006	10,000	10,000
Berries	10,000	6,012	10,000	10,000
Workers[b]:				
Pilot	2,376	987	10,000	7,899
Aerial mixer/loader	8,579	1,635	10,000	10,000
Observer/environmental evaluation team	679	311	5,435	2,486
Hiboy operator	8	-1	66	7
Mist blower operator	9	4	73	33
Accidents:				
Spill of concentrate		-66		-8
Broken hose		-17		-2
Immediate field reentry		1,748		10,000
Direct spray—adult		269		2,153
Drinking reservoir water/release		239		1,913
Eating berries—direct spray		700		5,600
Eating legumes—direct spray		350		2,800

Note: MOSs greater than 10,000 are listed as 10,000. MOSs are based on a systemic NOEL of 1 and a reproductive NOEL >8.

[a]Public exposures: typical at 100 feet, extreme at 25 feet.
[b]Worker exposures: typical is based on average dose, extreme is based on upper 95% confidence level.

4.60 in 1 million, respectively. The calculated cancer risk also exceeds 1 in 1 million for diflubenzuron exposure to hiboy operators (7.45 in 1 million) and mist blower operators (3.47 in 1 million). The risk of cancer for all other workers is less than 1 in 1 million. Accidental exposures to workers can also result in elevated cancer risk probabilities. Risks from malathion are 4.81 in 100,000 from spilled concentrate or spray from a broken hose. Estimated cancer probabilities as a result of diflubenzuron exposure are 6.03 in 100,000 from spilled concentrate on the skin and 2.41 in 10,000 from being sprayed from a broken hose. For both insecticides, cancer risks are less than 1 in 1 million for immediate reentry to a treated area.

Wildlife and Aquatic Species Risk Assessment

This section contains the quantitative risk assessment to determine the potential effects of insecticide use on the wildlife and aquatic species in central and northern Alabama, should the program expand into these areas of the state. The wildlife risk assessment includes risks to mammals, birds, amphibians, reptiles, and nontarget terrestrial invertebrates. The aquatic species risk assessment includes risks to fish and aquatic invertebrates.

Table A-23. Control program margins of safety for METHYL PARATHION

Exposure scenario	Systemic		Reproductive	
	Typical	Extreme	Typical	Extreme
Public[a]:				
Dermal and inhalation:				
Drift	34	13	344	134
Dietary:				
Water	10,000	10,000	10,000	10,000
Fish	801	4,985	8,014	10,000
Venison	4,455	391	10,000	3,914
Legumes	49	19	490	188
Berries	98	38	980	377
Workers[b]:				
Pilot	15	6	148	62
Aerial mixer/loader	54	10	536	102
Observer/environmental evaluation team	8	2	77	16
Hiboy operator	-5	-43	2	-4
Mist blower operator	-5	-10	2	0
Accidents:				
Spill of concentrate		-2,533		-253
Broken hose		-1,267		-127
Immediate field reentry		44		437
Direct spray—adult		2		17
Drinking reservoir water/release		3		31
Eating berries—direct spray		4		44
Eating legumes—direct spray		2		22

Note: MOSs greater than 10,000 are listed as 10,000. MOSs are based on a systemic NOEL of 0.025 and a reproductive NOEL of 0.25.

[a]Public exposures: typical at 100 feet, extreme at 25 feet.
[b]Worker exposures: typical is based on average dose, extreme is based on upper 95% confidence level.

The wildlife and aquatic species risk assessment consists of three analytic elements: a hazard analysis, an exposure analysis, and a risk analysis. A hazard analysis requires the gathering of information to determine the toxic properties of each insecticide. Species hazard levels are derived from field studies and from the results of laboratory studies of animals, such as rats, mice, rabbits, and fish. An exposure analysis involves the calculation of insecticide exposures to nontarget species and the estimation of the doses likely to result from those exposures. A risk analysis requires the comparison of the hazard information with the dose estimates to predict the toxic effects to wildlife and aquatic species during the given conditions of exposure.

Wildlife and Aquatic Species Hazard Analysis

This section presents a review of toxicological information on the hazards to wildlife and aquatic species from the three insecticides—malathion, diflubenzuron, and methyl parathion—considered for use in Alabama. For each insecticide, its toxicity to mammals, birds, insects, fish, aquatic invertebrates, reptiles, and amphibians is presented as a result of laboratory and field studies.

Table A-24. Control program lifetime cancer risks

Exposure scenario	Risk	
	Malathion[a]	Diflubenzuron[b]
Public:		
Dermal and inhalation:		
Drift	0.0000000208	0.0000000126
Dietary:		
Water	0.0000000000133	0.00000000000141
Fish	0.000000000123	0.0000000000352
Venison	0.0000000000398	0.0000000000193
Legumes	0.00000000204	0.00000000100
Berries	0.00000000102	0.000000000501
Workers:		
Pilot	0.000000230	0.000000242
Aerial mixer/loader	0.0000000792	0.00000000838
Observer/environmental	0.000000312	0.0000000465
evaluation team	0.00000733	0.00000745
Hiboy operator	0.00000460	0.00000347
Mist blower operator		
Accidents:		
Spill of concentrate	0.0000481	0.0000603
Broken hose	0.0000481	0.000241
Immediate field reentry	0.0000000000516	0.000000000287
Direct spray—adult	0.00000000420	0.00000000250
Drinking reservoir water/release	0.0000000110	0.00000000281
Eating berries—direct spray	0.00000000197	0.000000000961
Eating legumes—direct spray	0.00000000394	0.00000000192

Note: Risk calculations assume typical exposure 90% of the time and extreme exposure 10% of the time.

[a]Cancer risks are based on a cancer potency value of 0.00376 $(mg/kg/day)^{-1}$ (CDHS, 1980).

[b]Cancer risks are based on a cancer potency value of 0.01718 $(mg/kg/day)^{-1}$. The carcinogenicity information on diflubenzuron is inconclusive; however, because positive results were obtained in one study, a cancer risk analysis was conducted (EPA, 1979).

Appendix B of volume 1 of the Draft EIS contains a complete description of the hazard analyses for malathion, diflubenzuron, and methyl parathion. Based on a reassessment of the available data, one change has been made in the malathion hazard analysis: the lowest LD_{50} for the rat is now reported as 1,375 mg/kg (Gaines, 1960; as cited in Dobroski and Lambert, 1984).

Wildlife and Aquatic Species Exposure Analysis

This section presents the methodologies used to estimate exposures to wildlife and aquatic species from the three insecticides proposed for use in Alabama. To assess the control program's potential risk to nontarget species, exposures were calculated for a group of wildlife and aquatic species representative of those that typically inhabit the state of Alabama. These species represent a range of animal classes, body sizes, and diets for which biological parameters are generally available.

Appendix B of volume 1 of the Draft EIS contains a complete description of the methodologies used for the exposure analysis. Based on a reevaluation of the procedures,

however, several of the formulas used in the terrestrial wildlife exposure analysis have been modified to provide a more sensitive estimate of actual wildlife exposures. Note the following modifications to the vegetation contact percent (VCP) and percentage of body surface groomed (PBG) formulas, where BWT = body weight:

$$VCP = 1.3\ [BWT\ (g)]^{-0.1}$$

$$PBG = 1.7\ [BWT\ (g)]^{-0.3}$$

Also, the formulas for indirect dermal exposure (IND) and percentage of food contaminated (PFC) were incorrectly presented in appendix B. The corrected formulas should appear as follows:

$$IND\ (mg) = \text{Residues on leaves}\ (mg/cm^2) \times BSA\ (cm^2) \times MVT \times VCP$$

$$PFC = 100 \times [1/BWT\ (g)]^{0.2}$$

where BSA is body surface area (cm^2) and MVT is a movement factor, based on the phylogenetic class.

A more accurate insecticide drift analysis has been performed since the publication of volume 1 of the Draft EIS. Consequently, the new concentration of insecticide in an onsite pond that receives drift residues from a distance of 25 feet was calculated to be 0.0213 ppm for each pound of insecticide applied per acre.

In addition to the changes in to the terrestrial wildlife exposure analysis, several changes were made to the aquatic species exposure analysis to make that analysis more sensitive for the fish, clams, and aquatic reptiles native to Alabama. To analyze the effects of runoff on aquatic species in central Alabama, another large river, the Alabama River, was modeled using the EXAMS methodology. Also, a second runoff model, GLEAMS, was used to analyze the effects of runoff on nontarget aquatic organisms in small rivers, streams, or headwaters. While the EXAMS model is appropriate for large rivers such as the Tennessee and Alabama, manipulations of results from the GLEAMS model are better suited for calculating runoff concentrations of insecticide in small rivers and streams. By examining the GLEAMS results with specific watershed data, such as stream base flow, watershed drainage area, and total watershed cotton acreage, insecticide concentrations in site-specific habitats were obtained. Thus, depending on the size of a given aquatic species' habitat, either the EXAMS or GLEAMS model was selected to calculate the concentrations of insecticide in river or stream water that would be attributable to runoff. The results of the runoff calculations were then added to drift estimates to calculate the total typical and extreme estimated environmental concentrations (EECs) of insecticide in each sensitive habitat.

The farm pond exposure scenarios also were revised for this site-specific assessment. Specifically, four different scenarios were used to calculate concentrations of insecticides in a circular farm pond 1 acre in area and 2 feet in depth. The total runoff to the pond included drainage from 30 acres of cotton field, drainage from 3 acres of additional area (access roads, idle land, and so forth), and the precipitation falling on the pond surface.

The following assumptions were used to calculate the insecticide concentrations in each scenario:

Drift Scenario: Drift concentrations were calculated assuming a buffer of 25 feet between the edge of the field and the edge of the pond. A wind speed of 10 miles per hour was assumed to cause drift on the pond over one-half of its circumference. The area under the drift deposition curve between the two shorelines of the pond was used to determine the total drift per foot of shoreline.

Average Runoff Scenario: Average runoff concentrations were computed assuming that a large storm occurs 2 days after an insecticide application. Because data for storms of varying length and intensity were available, the storm that gave the maximum insecticide concentration in the GLEAMS output was chosen. A total area of 34 acres contributed runoff to the pond, 30 acres of treated cotton fields, 3 acres of additional land, and the pond itself.

Maximum Runoff Scenario: Maximum runoff concentrations were computed assuming that a small storm occurs on the same day that a cotton field has been sprayed. This storm is not large enough to produce runoff, but is large enough to dislodge the insecticide from the foliage. The next day the fields are resprayed and a large storm occurs 1 day later. The storm is assumed to be equivalent to the storm used in the average runoff scenario. A total area of 34 acres again contributed runoff to the pond, including 30 acres of treated cotton fields, 3 acres of additional land, and the pond itself.

Pond Surface Spray Scenario: Spray concentrations were calculated assuming that an application plane applies a single accidental swath of insecticide to a farm pond. It is further assumed that all insecticide from the swath lands on the pond surface.

The results of these exposure scenarios are presented in table A-25. For the aquatic species risk assessment, the two highest concentrations from the drift, average runoff, and maximum runoff scenarios were assumed to represent the typical and extreme farm pond EECs. However, because the two runoff scenarios produced higher concentrations than the drift scenario for all three insecticides, the average runoff scenario was used to represent the typical case and the maximum runoff scenario was used to represent the extreme case. The pond surface spray scenario was not included in the final assessment of risk because this scenario represents a worst case, accidental situation that should be prevented by proper operational procedures.

Wildlife and Aquatic Species Risk Analysis

This section considers the potential effects of malathion, diflubenzuron, and methyl parathion on nontarget species for the proposed expansion of the boll weevil control program into central and northern Alabama. The risks of insecticide use to wildlife and aquatic species are directly related to the inherent toxicity of each insecticide and the amount of

Table A-25. Farm pond EECs for four exposure scenarios

Insecticide	EECs (mg/L)			
	Drift	Average runoff	Maximum runoff	Direct spray
Malathion	0.0115	0.0455	0.168	0.0870
Diflubenzuron	0.00123	0.00261	0.00483	0.00929
Methyl parathion	0.00492	0.00946	0.0306	0.0372

insecticide (dose) individual organisms ingest during boll weevil control program operations. The wildlife and aquatic species risk analysis compares estimated acute exposures of representative species with the acute toxicity levels determined in laboratory studies.

Wildlife Risk Analysis

Estimation of Wildlife Risks. The criterion EPA (1986) uses in its ecological risk assessment of nontarget species was used to determine the risks to the different representative wildlife species and the relative risks among the three insecticides. The EPA criterion calls for a comparison of the dose received by an animal with the laboratory-determined LD_{50} for the most closely related laboratory test species.

For nonendangered terrestrial wildlife species, EPA (1986) assessed the risk of pesticide exposure according to the following scale:

Slight—Expected Dose <1/5 LD_{50}

Moderate—1/5 LD_{50} ≤ Expected Dose <LD_{50}

Significant—Expected Dose ≥ LC_{50}

Doses below the 1/5 LD_{50} level (slight) are assumed to present a low or negligible risk, doses between the 1/5 LD_{50} level and the LD_{50} (moderate) are assumed to present a risk that may be mitigated by the restricted use of pesticide, and doses above the LD_{50} (significant) are assumed to present an unacceptable risk.

Risks to Wildlife. The potential risks to representative wildlife species in Alabama are presented in tables A-26 through A-28. Each table presents the total typical and extreme dose estimates for the representative nontarget species. The LD_{50}s for the indicator species and the subsequent 1/5 LD_{50} values are also provided. Any doses that exceed the 1/5 LD_{50} criterion are noted.

Malathion—According to the results of the wildlife risk assessment, the honey bee is the only representative wildlife species likely to be affected by the use of malathion. Because the extreme dose estimate greatly exceeds the LD_{50}, any honey bees in or adjacent to a cotton field during spraying operations are likely to be killed.

Table A-26. Risks to representative wildlife species from MALATHION

Representative species	Typical dose estimate (mg/kg/day)	Extreme dose estimate (mg/kg/day)	1/5 LD_{50} (mg/kg)	LD_{50} (mg/kg)	Indicator species
Birds:					
Eastern kingbird (*Tyrannus tyrannus*)	1.08	47.5	80.0	400	Bobwhite
Northern bobwhite (*Colinus virginianus*)	0.382	17.3	80.0	400	Bobwhite
American kestrel (*Falco sparverius*)	0.619	38.6	80.0	400	Bobwhite
Belted kingfisher (*Megacercyle alcyon*)	0.365	14.5	297.0	1,485	Mallard
Mammals:					
Eastern cottontail (*Sylvilagus floridanus*)	0.128	14.5	50.0	250	Rabbit
Cottonmouse (*Peromyscus gossypinus*)	1.59	70.2	101.0	507	Mouse
White-tailed deer (*Odocoileus virginianus*)	0.017	2.68	10.6	53	Cattle
Red fox (*Vulpes fulva*)	0.073	6.17	275.0	1,375	Rat
Reptiles:					
Eastern hognose snake (*Heterodon platyrhinos*)	0.526	43.4	80.0	400	Bobwhite
Amphibians:					
Fowler's toad (*Bufo woodhousei fowleri*)	0.677	29.5	80.0	400	Bobwhite
Insect:					
Honey bee (*Apis mellifera*)	0.311	40.3[a]	1.182	5.908	Honey bee
Domestic animals:					
Cow	0.00783	3.28	10.6	53.0	Cow
Chicken	0.0876	4.13	30.0	150.0	Chicken
Dog	0.0365	1.50	275.0	1,375.0	Rat

[a]Estimated dose exceeds EPA (1986) risk criterion of 1/5 LD_{50}.

Table A-27. Risks to representative wildlife species from DIFLUBENZURON

Representative species	Typical dose estimate (mg/kg/day)	Extreme dose estimate (mg/kg/day)	1/5 LD_{50} (mg/kg)	LD_{50} (mg/kg)	Indicator species
Birds:					
Eastern kingbird (*Tyrannus tyrannus*)	0.112	5.00	400	2,000	Mallard
Northern bobwhite (*Colinus virginianus*)	0.0402	1.88	400	2,000	Mallard
American kestrel (*Falco sparverius*)	0.0645	4.08	400	2,000	Mallard
Belted kingfisher (*Megacercyle alcyon*)	0.0493	1.80	400	2,000	Mallard
Mammals:					
Eastern cottontail (*Sylvilagus floridanus*)	0.0139	1.51	928	4,640	Rat
Cottonmouse (*Peromyscus gossypinus*)	0.166	7.51	928	4,640	Mouse
White-tailed deer (*Odocoileus virginianus*)	0.00194	0.283	928	4,640	Rat
Red fox (*Vulpes fulva*)	0.00801	0.713	928	4,640	Rat
Reptiles:					
Eastern hognose snake (*Heterodon platyrhinos*)	0.0566	4.65	400	2,000	Mallard
Amphibians:					
Fowler's toad (*Bufo woodhousei fowleri*)	0.0839	3.65	400	2,000	Mallard
Insects:					
Honey bee (*Apis mellifera*)	0.032	4.13	191	957	Honey bee
Domestic Animals:					
Cow	0.000902	0.340	928	4,640	Rat
Chicken	0.0102	0.873	400	2,000	Mallard
Dog	0.00408	0.168	928	4,640	Rat

Table A-28. Risks to representative wildlife species from METHYL PARATHION

Representative species	Typical dose estimate (mg/kg/day)	Extreme dose estimate (mg/kg/day)	1/5 LD_{50} (mg/kg)	LD_{50} (mg/kg)	Indicator species
Birds:					
Eastern kingbird (*Tyrannus tyrannus*)	0.446	19.7[a]	2.0	10.0	Red-winged blackbird
Northern bobwhite (*Colinus virginianus*)	0.160	7.30[a]	1.51	7.56	Bobwhite
American kestrel (*Falco sparverius*)	0.258	16.1[a]	0.616	3.08	American kestrel
Belted kingfisher (*Megacercyle alcyon*)	0.188	6.98[a]	1.32	6.60	Mallard
Mammals:					
Eastern cottontail (*Sylvilagus floridanus*)	0.0554	6.05	84.0	420.0	Rabbit
Cottonmouse (*Peromyscus gossypinus*)	0.658	29.2[a]	4.6	23.0	Mouse
White-tailed deer (*Odocoileus virginianus*)	0.00775	1.13[a]	0.72	3.6	Rat
Red fox (*Vulpes fulva*)	0.0318	2.66	18.0	90.0	Dog
Reptiles:					
Eastern hognose snake (*Heterodon platyrhinos*)	0.226	18.4[a]	1.51	7.56	Bobwhite
Amphibians:					
Fowler's toad (*Bufo woodhousei fowleri*)	0.335	14.6[a]	1.51	7.56	Bobwhite
Insect:					
Honey bee (*Apis mellifera*)	0.128[a]	16.5[a]	0.102	0.508	Honey bee
Domestic Animals:					
Cow	0.00361	1.36[a]	0.72	3.6	Rat
Chicken	0.0381	2.05[a]	1.51	7.56	Bobwhite
Dog	0.0163	0.672	18.00	90.00	Dog

[a]Estimated dose exceeds EPA (1986) risk criterion of 1/5 LD_{50}.

Diflubenzuron—The wildlife risk assessment indicates that none of the representative wildlife species in Alabama will be adversely affected by the use of diflubenzuron because none of the typical or extreme dose estimates exceed the 1/5 LD_{50} value.

Methyl Parathion—The use of methyl parathion in the proposed expansion of the control program may present only a moderate risk to honey bees that receive a typical dose of the insecticide. However, an extreme dose of methyl parathion may present a significant risk to the honey bee. Extreme doses may also present moderate risks to the northern bobwhite, white-tailed deer, cow, and chicken, and significant risks to the eastern kingbird, American kestrel, belted kingfisher, cotton mouse, eastern hognose snake, and Fowler's toad.

Aquatic Species Risk Analysis

Estimation of Aquatic Species Risks. EPA's (1986) ecological risk assessment analyzes potential risks to aquatic species by comparing the dose received by an animal with the laboratory-determined LC_{50} for the most closely related laboratory test species. Thus, the following risk categories were used to assess the control program's effect on nontarget aquatic species in Alabama:

Slight—EEC $<1/10\ LC_{50}$

Moderate—$1/10\ LC_{50} \leq$ EEC $<1/2\ LC_{50}$

Significant—EEC $\geq 1/2\ LC_{50}$

Note that the risks to clams and aquatic reptiles were not quantified in volume 1 of the Draft EIS because no information was available on the toxicity of the three control program insecticides to these organisms. In this site-specific assessment, however, a risk assessment was conducted for clams and aquatic reptiles by pairing each species with a toxicity surrogate, or the most closely related aquatic species for which laboratory toxicity data exist. The American oyster, a saltwater bivalve species, was used as a toxicity surrogate for the effects of malathion on freshwater mussel species in Alabama. To determine the effects of diflubenzuron and methyl parathion on freshwater clams, fish were used as toxicity surrogates because the evidence suggests that known fish toxicants are comparatively less toxic to freshwater mussels during acute exposure (Havlik and Marking, 1987).

For aquatic reptiles, juvenile amphibians and a fish species were used as toxicity surrogates because such organisms are likely to be more susceptible to insecticide exposure than reptiles. Aquatic reptiles generally possess highly impervious shells or skin, which reduces the possibility of dermal exposure, and have lungs that require periodic resurfacing for fresh oxygen. However, tadpoles and fish have more permeable skin and rely solely on filtered water for oxygen. Consequently, the use of such organisms as toxicity surrogates is a conservative assumption that probably overstates the risk of insecticide exposure to aquatic reptiles. The tadpole of the western chorus frog was used as the toxicity surrogate for malathion and methyl parathion, and the channel catfish was used for diflubenzuron.

Risks to Aquatic Species. The potential risks to representative aquatic species in Alabama are presented in tables A-29 through A-31. Each table presents the total typical and extreme EECs for the water bodies containing the representative nontarget species. The LC_{50}s for the indicator species and the subsequent 1/10 LD_{50} values are also provided. Any doses that exceed the 1/10 LD_{50} criterion were noted.

Malathion—According to the results of the aquatic species risk assessment, the use of malathion in Alabama may present a significant risk to any bluegills or eastern painted turtles that live in farm ponds receiving either typical or extreme EECs of the insecticide. Also, largemouth bass in farm ponds face a moderate risk from the typical EEC and a significant risk from the extreme EEC, while farm pond populations of Fowler's toad (tadpole) face a moderate risk from both the typical and extreme EECs.

The results also indicate that the walleye faces a significant risk from the extreme EEC of malathion in the Cahaba River, while the scud, the stonefly (first year class), and the first instar of *Daphnia magna* face significant risks from both the typical and extreme EECs in the Cahaba, Tennessee, and Alabama Rivers.

Diflubenzuron—The aquatic species risk assessment indicates that none of the representative aquatic species in Alabama will be adversely affected by the use of diflubenzuron because none of the typical or extreme EECs exceed the 1/10 LC_{50} value.

Methyl Parathion—None of the fish, clams, aquatic reptiles, or amphibians in Alabama should be adversely affected by the use of methyl parathion. However, the risk assessment indicates that some species of aquatic invertebrates may be at risk during the boll weevil control program. For example, both the typical and extreme EECs in the Tennessee River present a significant risk to the first instar of *Daphnia magna* and a moderate risk to the first instar of the daphnid *Simocephalus serrulatus*. Also, the extreme EEC of methyl parathion in the Cahaba River presents a significant risk to crayfish.

Thus, methyl parathion may cause short-term population declines in some aquatic invertebrate populations. These declines could, in turn, have some adverse effects on aquatic vertebrate species. Both effects should be relatively short-lived because any concentrations of methyl parathion will dissipate rapidly from degradation and dilution; and in general, these species have high reproductive capacities.

Table A-29. Risks to representative aquatic species from MALATHION

Representative species	Representative habitat	Typical EEC (mg/L)	Extreme EEC (mg/L)	1/10 LC_{50} (mg/L)	LC_{50} or EC_{50} (mg/L)	Indicator species
Fish:						
Black crappie (*Pomoxis nigromaculatus*)	Alabama River	0.00167	0.00206[a]	0.0020	0.020	Bluegill
Bluegill (*Lepomis macrochirus*)	Farm pond	0.0455[a]	0.168[a]	0.0020	0.020	Bluegill
Channel catfish (*Ictalarus punctatus*)	Tennessee River	0.00036	0.0004	0.8970	8.970	Channel catfish
Largemouth bass (*Micropterus salmoides*)	Farm pond	0.0455[a]	0.168[a]	0.0285	0.285	Largemouth bass
Walleye (*Stizostedion vitreum*)	Cahaba River	0.00065	0.00994[a]	0.0020	0.020	Bluegill
Clams:						
Alabama spike mussel (*Elliptio raca*)	Alabama River	0.00167	0.00206	0.9070	9.070[b]	American oyster
Ebony shell mussel (*Fusconaia ebenea*)	Tennessee River	0.00036	0.0004	0.9070	9.070[b]	American oyster
Aquatic Reptiles:						
Banded water snake (*Natrix sipedon fasciata*)	Alabama River	0.00167	0.00206	0.0200	0.200	Western chorus frog (tadpole)
Eastern painted turtle (*Chrysemys picta picta*)	Farm pond	0.0455[a]	0.168[a]	0.0200	0.0200	Western chorus frog (tadpole)
Invertebrates:						
Aquatic sowbug (*Asellus brevicaudus*)	Cahaba River	0.00065	0.00994	0.300	3.00	Aquatic sowbug
Daphnia magna, 1st instar	Tennessee River	0.00036[a]	0.0004[a]	0.0001	0.001	1st instar
Scud (*Gammarus fasciatus*)	Alabama River	0.00167[a]	0.00206[a]	0.000076	0.00076	Scud
Stonefly, first year class (*Pteronarcella badia*)	Cahaba River	0.00065[a]	0.00994[a]	0.00011	0.0011	Stonefly

Table A-29. Risks to representative aquatic species from MALATHION (continued)

Representative species	Representative habitat	Typical EEC (mg/L)	Extreme EEC (mg/L)	1/10 LC_{50} (mg/L)	LC_{50} or EC_{50} (mg/L)	Indicator species
Amphibians:						
Fowler's toad (tadpole) (*Bufo woodhousei fowleri*)	Farm pond	0.0455[a]	0.168[a]	0.0420	0.420	Fowler's toad (tadpole)

[a]Exceeds EPA (1986) risk criterion of 1/10 LC_{50} for nonendangered aquatic species.
[b]48-hour median threshold limit (TLm).

Table A-30. Risks to representative aquatic species from DIFLUBENZURON

Representative species	Representative habitat	Typical EEC (mg/L)	Extreme EEC (mg/L)	1/10 LC_{50} (mg/L)	LC_{50} or EC_{50} (mg/L)	Indicator species
Fish:						
Black crappie (*Pomoxis nigromaculatus*)	Alabama River	0.0000051	0.0000053	37.0	370.0	Channel catfish
Bluegill (*Lepomis macrochirus*)	Farm pond	0.00261	0.00483	66.0	660.0	Bluegill
Channel catfish (*Ictalurus punctatus*)	Tennessee River	0.000015	0.000016	37.0	370.0	Channel catfish
Largemouth bass (*Micropterus salmoides*)	Farm pond	0.00261	0.00483	37.0	370.0	Channel catfish
Walleye (*Stizostedion vitreum*)	Cahaba River	0.000038	0.0011	37.0	370.0	Channel catfish
Clams:						
Alabama spike mussel (*Elliptio raca*)	Alabama River	0.0000051	0.0000053	37.0	370.0	Channel catfish
Ebony shell mussel (*Fusconaia ebenea*)	Tennessee River	0.000015	0.000016	37.0	370.0	Channel catfish
Aquatic reptiles:						
Banded water snake (*Natrix sipedon fasciata*)	Alabama River	0.0000051	0.0000053	37.0	370.0	Channel catfish
Eastern painted turtle (*Chrysemys picta picta*)	Farm pond	0.00261	0.00483	37.0	370.0	Channel catfish
Invertebrates:						
Daphnia magna, 1st instar	Tennessee River	0.000015	0.000016	0.0015	0.015	1st instar
Scud (*Gammarus pseudolimnaeus*)	Alabama River	0.0000051	0.0000053	0.0025	0.025	Scud
Stonefly, first year class (*Skwala* spp.)	Cahaba River	0.000038	0.0011	5.75	57.5	Stonefly

Table A-31. Risks to representative aquatic species from METHYL PARATHION

Representative species	Representative habitat	Typical EEC (mg/L)	Extreme EEC (mg/L)	1/10 LC_{50} (mg/L)	LC_{50}, EC_{50}, or TLm (mg/L)	Indicator species
Fish:						
Black crappie (*Pomoxis nigromaculatus*)	Alabama River	0.000263	0.000307	0.306	3.06	Yellow perch
Bluegill (*Lepomis macrochirus*)	Farm pond	0.00946	0.0306	0.438	4.38	Bluegill
Channel catfish (*Ictalurus punctatus*)	Tennessee River	0.000058	0.000066	0.524	5.24	Channel catfish
Largemouth bass (*Micropterus salmoides*)	Farm pond	0.00946	0.0306	0.522	5.22	Largemouth bass
Walleye (*Stizostedion vitreum*)	Cahaba River	0.00016	0.0042	0.306	3.06	Yellow perch
Clams:						
Alabama spike mussel (*Elliptio raca*)	Alabama River	0.000263	0.000307	0.306	3.06	Yellow perch
Ebony shell mussel (*Fusconaia ebenea*)	Tennessee River	0.000058	0.000066	0.306	3.06	Yellow perch
Aquatic reptiles:						
Banded water snake (*Natrix sipedon fasciata*)	Alabama River	0.000263	0.000307	0.370	3.70	Western chorus frog (tadpole)
Eastern painted turtle (*Chrysemys picta picta*)	Farm pond	0.00946	0.0306	0.370	3.70	Western chorus frog (tadpole)
Invertebrates:						
Crayfish (*Procambarus clarki*)	Cahaba River	0.00016	0.0042[a]	0.0003	0.003	Crayfish
Damselfly, late instar (*Ischnuva verticalis*)	Alabama River	0.000263	0.000307	0.0033	0.033	Damselfly
Daphnid, 1st instar (*Simocephalus serrulatus*)	Tennessee River	0.000058[a]	0.000066[a]	0.000037	0.00037	Daphnid
Daphnia magna, 1st instar	Tennessee River	0.000058[a]	0.000066[a]	0.000014	0.00014	1st instar

Table A-31. Risks to representative aquatic species from METHYL PARATHION (continued)

Representative species	Representative habitat	Typical EEC (mg/L)	Extreme EEC (mg/L)	1/10 LC_{50} (mg/L)	LC_{50}, EC_{50}, or TLm (mg/L)	Indicator species
Amphibians:						
Upland chorus frog (tadpole) (*Pseudacris triseriata triseriata*)	Farm pond	0.00946	0.0306	0.370	3.70	Western chorus frog (tadpole)

[a]Exceeds EPA (1986) risk criterion of 1/10 LC_{50} for nonendangered aquatic species.

Appendix B

Federally Listed Endangered, Threatened, and Proposed Species in Alabama

Introduction

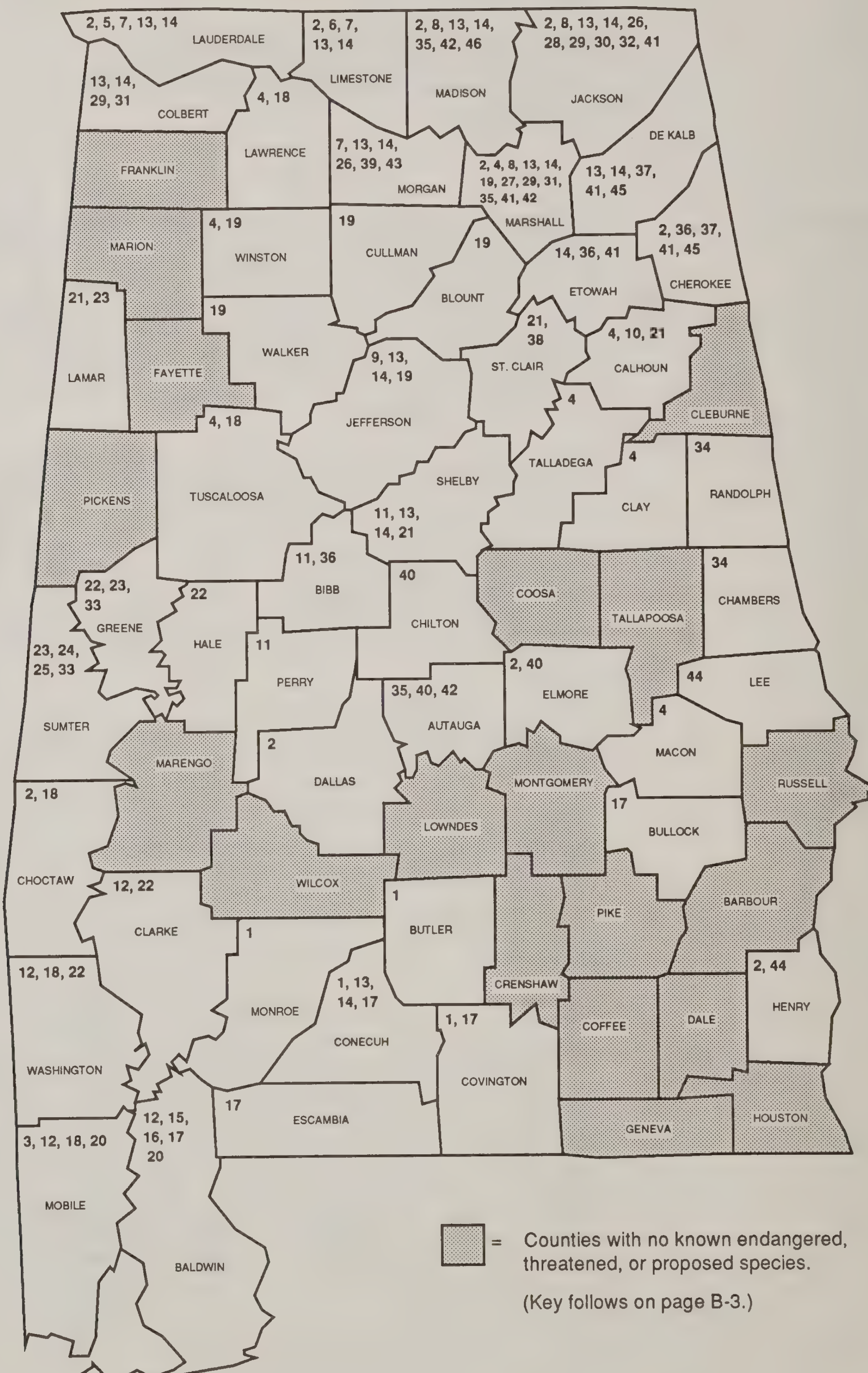
The U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) has proposed a National Boll Weevil Cooperative Control Program to be implemented in 17 southern states across the U.S. Cotton Belt. In 1989 APHIS prepared and published a draft environmental impact statement (DEIS) describing the potential impacts of the program on the human environment. The preferred alternative of the cooperative program is full federal involvement in eradicating the boll weevil as an economic cotton pest in the United States.

In addition, APHIS has prepared a biological assessment in accordance with the Endangered Species Act of 1973, as amended. It is intended to initiate formal consultation between APHIS and the Fish and Wildlife Service of the U.S. Department of the Interior (USDI). It assesses the impact the proposed National Boll Weevil Cooperative Control Program may have on the 198 federally listed endangered, threatened, and proposed species in cotton-producing areas and was used to determine what protection measures would ensure that those species are not jeopardized by the program.

This appendix assesses the potential risk that may be posed by implementing the National Boll Weevil Cooperative Control Program in the State of Alabama to each of the state's 46 federally listed endangered, threatened, and proposed species. The assessment is based on the nontarget species risk assessment included in the 1989 Draft EIS conducted for the National Boll Weevil Cooperative Control Program and on specific life-history information gathered on each species. It consists of a risk assessment discussion and a species-specific assessment section with a description of the kinds of protection measures recommended for endangered, threatened, and proposed species in Alabama.

Figure B-1 indicates the geographical distribution of these endangered, threatened, and proposed species. Table B-1 summarizes the potential risk to individual species and shows that "no effect" is anticipated for 12 species because of their geographic distribution or because their habitat is not close to the agricultural lands to be treated in the control program. However, 34 species were determined to be "may affect" cases because the species may be adversely affected by the direct toxic or indirect effects of the program insecticides or may be otherwise disturbed by boll weevil control measures or insecticide application methods (for example, the noise of the spray planes). Table B-1 also lists each species' scientific name and its counties of occurrence.

Fig. B-1. Location of endangered, threatened, and proposed species in the State of Alabama



= Counties with no known endangered, threatened, or proposed species.

(Key follows on page B-3.)

Key to Fig. B-1: Location of endangered, threatened, and proposed species in the State of Alabama

Amphibians
Red Hills salamander 1

Birds
Bald eagle 2
Piping plover 3
Red-cockaded woodpecker 4

Fish
Alabama cavefish 5
Boulder (Elk River) darter 6
Slackwater darter 7
Snail darter 8
Watercress darter 9
Pygmy sculpin 10
Cahaba shiner 11
Gulf sturgeon 12

Mammals
Gray bat 13
Indiana bat 14
Alabama beach mouse 15
Perdido Key beach mouse 16

Reptiles
Eastern indigo snake 17
Gopher tortoise 18
Flattened musk turtle 19
Alabama red-bellied turtle 20

Snail
Tulotoma snail 21

Clams
Inflated heelsplitter mussel 22
Judge Tait's mussel 23
Marshall's mussel 24
Penitent mussel 25
Alabama lamp pearly mussel 26
Orange-footed (=pimple back) pearly mussel 27
Pale lilliput pearly mussel 28
Pink mucket pearly mussel 29
Fine-rayed pigtoe 30
Rough pigtoe 31
Shiny pigtoe 32
Stirrup shell 33

Plants
Little amphianthus 34
Lyrate bladderpod 35
Mohr's Barbara's buttons 36
Harperella 37
Alabama leather flower 38
American hart's-tongue fern 39
Alabama canebreak pitcher-plant 40
Green pitcher-plant 41
Price's potato bean 42
Leafy prairie-clover 43
Relict trillium 44
Kral's water-plantain 45

Crustaceans
Alabama cave shrimp 46

Table B-1. Summary of potential risks from the National Boll Weevil Cooperative Control Program to endangered, threatened, and proposed species in Alabama

Common name	Scientific name	County	Conclusion
Mammals:			
Bat, gray	*Myotis grisescens*	Colbert Conecuh DeKalb Jackson Jefferson Lauderdale Limestone Madison Marshall Morgan Shelby	May affect
Bat, Indiana	*Myotis sodalis*	Colbert Conecuh DeKalb Jackson Jefferson Lauderdale Limestone Madison Marshall Morgan Shelby	May affect
Mouse, Alabama beach	*Peromyscus polionotus ammobates*	Baldwin	No effect
Mouse, Perdido Key beach	*Peromyscus polionotus trissyllepis*	Baldwin	No effect
Birds:			
Eagle, bald	*Haliaeetus leucocephalus*	Barbour Cherokee Choctaw Dallas Elmore Henry Jackson Lauderdale Limestone Madison Marshall	May affect
Plover, piping	*Charadrius melodus*	Mobile	May affect

Table B-1. Summary of potential risks from the National Boll Weevil Cooperative Control Program to endangered, threatened, and proposed species in Alabama (continued)

Common name	Scientific name	County	Conclusion
Birds (cont.):			
Woodpecker, red-cockaded	*Picoides* (=*Dendrocopos*) *borealis*	Calhoun Clay Lawrence Macon Marshall Talladega Tuscaloosa Winston	May affect
Reptiles:			
Snake, eastern indigo	*Drymarchon corais couperi*	Baldwin Bullock Conecuh Covington Escambia	May affect
Tortoise, gopher	*Gopherus polyphemus*	Choctaw Mobile Washington	May affect
Turtle, flattened musk	*Sternotherus depressus*	Blount Cullman Etowah Jefferson Lawrence Marshall Tuscaloosa Walker Winston	May affect
Turtle, Alabama red-bellied	*Pseudemys alabamensis*	Baldwin Mobile	May affect
Amphibians:			
Salamander, Red Hills	*Phaeognathus hubrichti*	Butler Conecuh Covington Monroe	No effect
Fish:			
Cavefish, Alabama	*Speoplatyrhinus poulsoni*	Lauderdale	May affect
Darter, boulder (=Elk River)	*Etheostoma wapiti*	Limestone	May affect

Table B-1. Summary of potential risks from the National Boll Weevil Cooperative Control Program to endangered, threatened, and proposed species in Alabama (continued)

Common name	Scientific name	County	Conclusion
Fish (cont.):			
Darter, slackwater	*Etheostoma boschungi*	Lauderdale Limestone Madison Morgan	May affect
Darter, snail	*Percina tanasi*	Jackson Madison Marshall	May affect
Darter, watercress	*Etheostoma nuchale*	Jefferson	No effect
Sculpin, pygmy	*Cottus pygmaeus*	Calhoun	No effect
Shiner, Cahaba	*Notropis cahabae*	Bibb Perry Shelby	May affect
Sturgeon, gulf	*Acipenser oxyrhynchus desotoi*	Baldwin Clarke Mobile Washington	May affect
Snail:			May affect
Snail, tulotoma	*Tulotoma magnifica*	Calhoun Coosa Elmore Shelby St. Clair	
Clams:			
Mussel, inflated heelsplitter	*Potamilus inflatus*	Clarke Green Hale Washington	May affect
Mussel, Judge Tait's	*Pleurobema taitianum*	Greene Lamar Sumter	May affect
Mussel, Marshall's	*Pleurobema marshalli*	Sumter	May affect
Mussel, penitent	*Epioblasma (=Dysnomia) penita*	Lamar Sumter	May affect
Pearly mussel, Alabama lamp	*Lampsilis virescens*	Jackson	May affect

Table B-1. Summary of potential risks from the National Boll Weevil Cooperative Control Program to endangered, threatened, and proposed species in Alabama (continued)

Common name	Scientific name	County	Conclusion
Clams (cont.):			
Pearly mussel, (=pimple back) orange-footed	*Plethobasus cooperianus*	Marshall	May affect
Pearly mussel, pale lilliput	*Toxolasma (=Carunculina) cylindrellus*	Jackson	May affect
Pearly mussel, pink mucket	*Lampsilis orbiculata*	Colbert Jackson Marshall Morgan Lauderdale	May affect
Pigtoe, fine-rayed	*Fusconaia cuneolus*	Jackson	May affect
Pigtoe, rough	*Pleurobema plenum*	Colbert Marshall	May affect
Pigtoe, shiny	*Fusconaia edgariana*	Jackson	May affect
Stirrup shell	*Quadrula stapes*	Greene Sumter	May affect
Crustaceans:			
Shrimp, Alabama cave	*Palaemonias alabamae*	Madison	May affect
Plants:			
Amphianthus, little	*Amphianthus pusillus*	Chambers Randolph	No effect
Bladder-pod, lyrate	*Lesquerella lyrata*	Franklin Colbert	No effect
Buttons, Mohr's Barbara's	*Marshallia mohrii*	Bibb Cherokee Etowah	May affect
Harperella	*Ptilimnium nodosum* (=*P. fluviatile*)	Cherokee DeKalb	May affect
Leather flower, Alabama	*Clematis socialis*	Cherokee St. Clair	May affect
Fern, American hart's-tongue	*Phyllitis scolopendrium* var. *americana* (=*P. japonica* ssp. *a.*)	Morgan	No effect

Table B-1. Summary of potential risks from the National Boll Weevil Cooperative Control Program to endangered, threatened, and proposed species in Alabama (continued)

Common name	Scientific name	County	Conclusion
Plants (cont.):			
Pitcher-plant, Alabama canebrake	*Sarracenia rubra* ssp. *alabamensis* (=*S. alabamensis* ssp. *a.*)	Autauga Chilton Elmore	No effect
Pitcher-plant, green	*Sarracenia oreophila*	Cherokee DeKalb Etowah Jackson Marshall	No effect
Potato-bean, Price's	*Apios priceana*	Autauga Madison Marshall	No effect
Prairie-clover, leafy	*Dalea foliosa*	Morgan	No effect
Trillium, relict	*Trillium reliquum*	Henry Lee	May affect
Water-plantain, Kral's	*Sagittaria secundifolia*	Chatooga Cherokee DeKalb	May affect

Risk Assessment for Federally Listed Endangered, Threatened, and Proposed Species

This section describes the methodologies used to analyze the potential risks to the 46 nontarget organisms. These nontarget organisms include mammals, birds, reptiles, an amphibian, fish, clams, a crustacean, insects, arachnids, and plants that are listed by the Fish and Wildlife Service as endangered, threatened, or proposed species and that may be affected by the use of the three chemical insecticides proposed for use in the National Boll Weevil Cooperative Control Program in Alabama. The results of the risk assessment are also presented in this chapter.

To assess the control program's potential risk to these species, a decision-tree analysis was performed for each species. The decision-tree consisted of a series of five questions posed for each of the 46 endangered, threatened, and proposed species. Specifically, the decision-tree questions were used to ascertain the following: (1) the occurrence of the species in cotton-producing counties, (2) the proximity of habitat areas to cotton fields or localities affected by cotton production, (3) direct toxicity to the species from insecticide exposure, (4) indirect effects to the species from insecticide application, and (5) the effects of application method disturbances on the species. If the answers to questions 1 or 2 were "no" for a given species, the analysis stopped at that decision point and an assessment of "no effect" was concluded for that species. If the answers to both questions 1 and 2 were "yes," a complete decision-tree analysis was performed for the species and the severity of the impact from insecticide exposure was determined.

Question 3 of the decision-tree analysis, or the risk of direct toxicity from insecticide exposure, is the key component of the endangered, threatened, and proposed species risk assessment. To answer this question, a quantitative risk assessment was performed. The quantitative risk assessment consisted of three analytic elements: a hazard analysis, an exposure analysis, and a risk analysis.

The hazard analysis required gathering information to determine the toxic properties of each of the program insecticides. For each pesticide, results of laboratory and field studies are presented on the insecticide's toxicity to mammals, birds, insects, plants, fish, aquatic invertebrates, aquatic plants, reptiles, and amphibians.

The exposure analysis involved estimating potential exposures of nontarget species to the program insecticides and determining what doses were likely to result from those estimated exposures. Exposures were calculated for a group of terrestrial wildlife and aquatic species representative of those that typically inhabit various regions of the Cotton Belt. These species represent a range of animal classes, body sizes, and diets for which information on these biological parameters is generally available. The exposures derived for the representative wildlife species were then assumed to apply to the endangered, threatened, and proposed species evaluated in this assessment. For terrestrial species, typical and extreme exposures were estimated for each representative species using conservative assumptions for routine application operations. In both the typical and extreme dose calculations, the three principal routes of exposure were examined: dermal, ingestion, and inhalation. For each aquatic habitat, the total concentration of each insecticide in water, or the estimated

environmental concentration (EEC), was calculated by adding estimated runoff concentrations to drift concentrations. Two quantitative models, the Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) and the Exposure Analysis Modeling System (EXAMS), were used to estimate runoff concentrations, and a third model, Agricultural Dispersion (AGDISP), was used to estimate drift concentrations from aerial insecticide applications. The analysis assumed that the aquatic organisms were exposed to insecticide residues by immersion in water bodies that had received varying levels of insecticide through runoff, drift, or direct spraying.

The risk analysis involved comparing the insecticide hazard information with the dose estimates to predict the toxic effects to wildlife and plants under the specified exposure conditions. Risks to wildlife and aquatic species from boll weevil control with insecticides are directly related to the inherent toxicity (hazard) of each insecticide to different organisms and to the amount of each chemical (dose) those organisms may take in as a result of boll weevil control operations. The wildlife and aquatic species risk analysis compares estimated acute exposures of representative species with the acute toxicity levels found in laboratory studies. For wildlife risks, the criterion the Environmental Protection Agency (EPA) uses in its ecological risk assessment (EPA, 1986) of endangered species was used to determine the risks to the different representative species and the relative risks among the three insecticides. The EPA criterion calls for a comparison of the dose received by an animal with the laboratory-determined median lethal dose (LD_{50}), which is the dose, usually administered orally, that kills 50% of the test animals for the most closely related laboratory test species. For endangered terrestrial wildlife species, EPA (1986) considers the risk to be unacceptable if the dose exceeds 1/10 the LD_{50}. Doses below this level are assumed to present a low or negligible risk.

To estimate the susceptibility of the endangered, threatened, and proposed aquatic species to the program insecticides, each species was paired with a common aquatic species for which acute toxicity reference values have been determined. These references values are either the median lethal concentration (LC_{50}), which is the concentration of a toxicant in the water that kills 50% of the text organisms within a specified time, or the concentration of a toxicant that produces a specific effect on 50% of the test organisms (EC_{50}), which is often used with animals where determining death is difficult, such as with *Daphnia* sp. The aquatic species most sensitive to the three insecticides were selected in each case. The toxicity reference values were then compared with the EECs of each insecticide. According to EPA (1986), the risk to endangered aquatic species is unacceptable if the EEC equals or exceeds 1/20 the LC_{50}.

For more detailed descriptions of the hazard, exposure, and risk analyses, and the models used to calculate aquatic exposures, refer to the National Boll Weevil Cooperative Control Program Draft EIS and the Analysis and Protection of Endangered and Threatened Species (APETS) supplement to the Draft EIS.

The potential risks to the federally listed endangered, threatened, and proposed wildlife species are presented in table B-2. The table presents the total typical and extreme

Table B-2. Risk to endangered, threatened, and proposed wildlife species in Alabama

Endangered, threatened, or proposed species	Nontarget representative species	Typical dose estimate (mg/kg/day)	Extreme dose estimate (mg/kg/day)	1/10 LD_{50} (mg/kg)	LD_{50} (mg/kg)	Indicator species
Malathion:						
Bat, gray (*Myotis grisescens*)	Deer mouse	1.59	70.2[a]	50.7	507	Mouse
Bat, Indiana (*Myotis sodalis*)	Deer mouse	1.59	70.2[a]	50.7	507	Mouse
Eagle, bald (*Haliaeetus leucocephalus*)	American kestrel	0.619	38.6	40	400	Bobwhite
Plover, piping (*Charadrius melodus*)	Belted kingfisher	0.365	14.5	148.5	1,485	Mallard
Woodpecker, red-cockaded (*Picoides* (=*Dendrocopos*) *borealis*)	Eastern kingbird	1.08	47.5[a]	40	400	Bobwhite
Snake, eastern indigo (*Drymarchon corais couperi*)	Western diamondback rattlesnake	0.526	43.4[a]	40	400	Bobwhite
Tortoise, gopher (*Gopherus polyphemus*)	Gopher tortoise	0.0177	4.55	40	400	Bobwhite
Diflubenzuron:						
Bat, gray (*Myotis grisescens*)	Deer mouse	0.166	7.51	464	4,640	Mouse
Bat, Indiana (*Myotis sodalis*)	Deer mouse	0.166	7.51	464	4,640	Mouse
Eagle, bald (*Haliaeetus leucocephalus*)	American kestrel	0.0645	4.08	200	2,000	Mallard
Plover, piping (*Charadrius melodus*)	Belted kingfisher	0.0493	1.80	200	2,000	Mallard

Table B-2. Risk to endangered, threatened, and proposed wildlife species in Alabama (continued)

Endangered, threatened, or proposed species	Nontarget representative species	Typical dose estimate (mg/kg/day)	Extreme dose estimate (mg/kg/day)	1/10 LD_{50} (mg/kg)	LD_{50} (mg/kg)	Indicator species
Woodpecker, red-cockaded (*Picoides* (=*Dendrocopos*) *borealis*)	Eastern kingbird	0.112	5.00	200	2,000	Mallard
Snake, eastern indigo (*Drymarchon corais couperi*)	Western diamondback rattlesnake	0.0566	4.65	200	2,000	Mallard
Tortoise, gopher (*Gopherus polyphemus*)	Gopher tortoise	0.00219	0.482	200	2,000	Mallard
Methyl parathion:						
Bat, gray (*Myotis grisescens*)	Deer mouse	0.658	29.2[a]	2.3	23	Mouse
Bat, Indiana (*Myotis sodalis*)	Deer mouse	0.658	29.2[a]	2.3	23	Mouse
Eagle, bald (*Haliaeetus leucocephalus*)	American kestrel	0.258	16.1[a]	0.308	3.08	American kestrel
Plover, piping (*Charadrius melodus*)	Belted kingfisher	0.188	6.98[a]	0.660	6.60	Mallard
Woodpecker, red-cockaded (*Picoides* (=*Dendrocopos*) *borealis*)	Eastern kingbird	0.446	19.7[a]	1	10	Red-winged blackbird
Snake, eastern indigo (*Drymarchon corais couperi*)	Western diamondback rattlesnake	0.226	18.4[a]	0.756	7.56	Bobwhite
Tortoise, gopher (*Gopherus polyphemus*)	Gopher tortoise	0.00874	1.93[a]	0.756	7.56	Bobwhite

dose estimates for endangered, threatened, and proposed species, as determined for the representative wildlife species. The LD_{50}s for the indicator species and the subsequent 1/10 of the LD_{50} values are also provided. Any doses that exceed the 1/10 LD_{50} criterion are noted. The risk to each individual species and the protection measures suggested to safeguard the species from such risk, if necessary, are discussed in the species-specific assessments that follow.

The risks to endangered, threatened, and proposed aquatic species are presented in tables B-3 and B-4. Table B-3 lists the total typical and extreme EECs calculated for fish and clams, as well as each species' actual or representative habitat area. These tables also list the LC_{50}s and the subsequent 1/20 LC_{50} values for each program insecticide. All EECs that exceed the 1/20 LC_{50} criterion are noted. In similar fashion, table B-4 presents the approximation of risk to aquatic reptiles. Note that the aquatic exposure methodologies used in this supplement were unable to calculate EECs for one fish species, the Alabama cavefish, and one crustacean species, the Alabama cave shrimp. For these species, qualitative analyses of probable risk were performed using the results of the risk assessment for the other endangered, threatened, or proposed aquatic species in this appendix.

The risk to each individual species and the protection measures suggested to safeguard the species from such risk, if necessary, are discussed in the species-specific assessments in this appendix.

Species-Specific Assessment of Endangered, Threatened, and Proposed Species

This section describes the management strategies and protection measures designed to prevent possible adverse impacts to Alabama's endangered, threatened, and proposed species. The implementation of these strategies and measures will require close field-level cooperation between APHIS and the Fish and Wildlife Service to identify current locations of species and to tailor the control program operations to protect these species.

The location of many species is often a dynamic factor dependent on climate, species migration, and natural occurrences, such as fire, floods, and severe weather. The location of individual cotton fields also is a dynamic factor dependent on weather and market economics. The dynamics of both species locations and cotton production must be closely monitored to avoid species impact.

The following assessment groups each taxa's potentially affected species into "no effect" and "may affect" groups. In the discussion on each species, the "Analysis of Program Impacts" section contains a summary of the decision-tree questions discussed in the risk analysis section and describes the manner in which a species might experience impact. Management strategies or protection measures are then prescribed to prevent those impacts. The "Conclusion" section contains a finding of "no effect" or "may affect."

The protection measures suggested for endangered, threatened, and proposed species in Alabama include prohibiting specific chemicals near some habitat areas, restricting the mode and proximity of application, and limiting the amount of cotton sprayed at any one time in a given watershed of concern.

Table B-3. Approximation of acute risk to endangered, threatened, and proposed fish and mollusk species in streams, headwaters, or rivers that receive contaminated runoff and drift from program chemicals in Alabama

Endangered, threatened, or proposed species	Common species	LC_{50} (mg/L)	1/20 LC_{50} (mg/L)	Representative habitat	EEC (mg/L) Typical	EEC (mg/L) Extreme
Malathion:						
Cavefish, Alabama	Bluegill	0.02	0.001	Key Cave[a]	___[b]	___[b]
Darter, boulder	Bluegill	0.02	0.001	Elk River[a]	0.0014	0.0074[c]
Darter, slackwater	Bluegill	0.02	0.001	Swan Creek, Flint and Buffalo Rivers[a]	0.0309[c]	0.0333[c]
Darter, snail	Bluegill	0.02	0.001	Paint Rock River[a]	0.000884	0.0154[c]
Shiner, Cahaba	Bluegill	0.02	0.001	Cahaba River[a]	0.000645	0.000994
Sturgeon, gulf	Bluegill	0.02	0.001	Alabama River	0.00168[c]	0.00206[c]
Snail, Tulotoma	Bluegill	0.02	0.001	Kelly Creek[a]	0.000711	0.0183[c]
Mussel, inflated heelsplitter	American oyster	9.07	0.4535	Alabama River	0.00167	0.00206
Mussel, Judge Tait's	American oyster	9.07	0.4535	Sipsey River[a]	0.000394	0.0134
Mussel, Marshall's	American oyster	9.07	0.4535	Tennessee River[a]	0.00036	0.0004
Mussel, penitent	American oyster	9.07	0.4535	Alabama River	0.00167	0.00206
Pearly mussel, Alabama lamp	American oyster	9.07	0.4535	Paint Rock River[a]	0.000884	0.00154
Pearly mussel, orange-footed	American oyster	9.07	0.4535	Tennessee River[a]	0.00036	0.0004
Pearly mussel, pale lilliput	American oyster	9.07	0.4535	Paint Rock River[a]	0.000884	0.0154
Pearly mussel, pink mucket	American oyster	9.07	0.4535	Tennessee River[a]	0.00036	0.0004
Pigtoe, fine-rayed	American oyster	9.07	0.4535	Elk and Paint Rock Rivers[a]	0.00139	0.00741
Pigtoe, rough	American oyster	9.07	0.4535	Tennessee River[a]	0.00036	0.0004

Table B-3. Approximation of acute risk to endangered, threatened, and proposed fish and mollusk species in streams, headwaters, or rivers that receive contaminated runoff and drift from program chemicals in Alabama (continued)

Endangered, threatened, or proposed species	Common species	LC_{50} (mg/L)	1/20 LC_{50} (mg/L)	Representative habitat	EEC (mg/L) Typical	Extreme
Malathion (cont.):						
Pigtoe, shiny	American oyster	9.07	0.4535	Paint Rock River[a]	0.000884	0.0154
Diflubenzuron:						
Cavefish, Alabama	Channel catfish	370	18.5	Key Cave[a]	—[b]	—[b]
Darter, boulder	Channel catfish	370	18.5	Elk River	0.0000526	0.000757
Darter, slackwater	Channel catfish	370	18.5	Swan Creek, Flint and Buffalo Rivers[a]	0.0013	0.0022
Darter, snail	Channel catfish	370	18.5	Paint Rock River[a]	0.000034	0.00163
Shiner, Cahaba	Channel catfish	370	18.5	Cahaba River	0.000038	0.00105
Sturgeon, gulf	Channel catfish	370	18.5	Alabama River	0.0000051	0.0000053
Snail, tulotoma	Channel catfish	370	18.5	Kelly Creek[a]	0.0000218	0.00194
Mussel, inflated heelsplitter	Channel catfish	370	18.5	Alabama River	0.0000051	0.0000053
Mussel, Judge Tait's	Channel catfish	370	18.5	Sipsey River[a]	0.0000185	0.00142
Mussel, Marshall's	Channel catfish	370	18.5	Tennessee River	0.000015	0.000016
Mussel, penitent	Channel catfish	370	18.5	Alabama River	0.0000051	0.0000053
Pearly mussel, Alabama lamp	Channel catfish	370	18.5	Paint Rock River[a]	0.000034	0.00163
Pearly mussel, orange-footed	Channel catfish	370	18.5	Tennessee River[a]	0.000015	0.000016
Pearly mussel, pale lilliput	Channel catfish	370	18.5	Paint Rock River[a]	0.000034	0.000163
Pearly mussel, pink mucket	Channel catfish	370	18.5	Tennessee River[a]	0.000015	0.000016
Pigtoe, fine-rayed	Channel catfish	370	18.5	Tennessee, Elk, and Paint Rock Rivers[a]	0.000053	0.00076
Pigtoe, rough	Channel catfish	370	18.5	Tennessee River[a]	0.000015	0.000016
Pigtoe, shiny	Channel catfish	370	18.5	Paint Rock River[a]	0.000034	0.00163

Table B-3. Approximation of acute risk to endangered, threatened, and proposed fish and mollusk species in streams, headwaters, or rivers that receive contaminated runoff and drift from program chemicals in Alabama (continued)

Endangered, threatened, or proposed species	Common species	LC_{50} (mg/L)	1/20 LC_{50} (mg/L)	Representative habitat	EEC (mg/L)	
					Typical	Extreme
Methyl parathion:						
Cavefish, Alabama	Yellow perch	3.06	0.153	Key Cave[a]	—[b]	—[b]
Darter, boulder	Yellow perch	3.06	0.153	Elk River[a]	0.00024	0.0031
Darter, slackwater	Yellow perch	3.06	0.153	Swan Creek, Flint and Buffalo Rivers[a]	0.005	0.078
Darter snail	Yellow perch	3.06	0.153	Tennessee River[a]	0.000059	0.000066
Shiner, Cahaba	Yellow perch	3.06	0.153	Cahaba River[a]	0.00016	0.0042
Sturgeon, gulf	Yellow perch	3.06	0.153	Alabama River[a]	0.000263	0.000307
Snail, tulotoma	Yellow perch	3.06	0.153	Kelly Creek[a]	0.000122	0.00778
Mussel, inflated heelsplitter	Yellow perch	3.06	0.153	Alabama River	0.000263	0.000307
Mussel, Judge Tait's	Yellow perch	3.06	0.153	Sipsey River[a]	0.000756	0.00569
Mussel, Marshall's	Yellow perch	3.06	0.153	Tennessee River[a]	0.000058	0.0000676
Mussel, penitent	Yellow perch	3.06	0.153	Alabama River[a]	0.000263	0.000307
Pearly mussel, Alabama lamp	Yellow perch	3.06	0.153	Paint Rock River[a]	0.000145	0.00654
Pearly mussel, orange-footed	Yellow perch	3.06	0.153	Tennessee River[a]	0.000058	0.000067
Pearly mussel, pale lilliput	Yellow perch	3.06	0.153	Paint Rock River[a]	0.000145	0.00654
Pearly mussel, pink mucket	Yellow perch	3.06	0.153	Tennessee River[a]	0.000059	0.000066
Pigtoe, fine-rayed	Yellow perch	3.06	0.153	Tennessee, Elk, and Paint Rock Rivers[a]	0.000287	0.000347
Pigtoe, rough	Yellow perch	3.06	0.153	Tennessee River[a]	0.000058	0.00066
Pigtoe, shiny	Yellow perch	3.06	0.153	Paint Rock River[a]	0.000145	0.000654

[a]Actual habitat area.
[b]Not available; the representative habitat could not be modeled using the GLEAMS methodology.
[c]Exceeds EPA (1986) risk criterion of 1/20 LC_{50} for endangered species.

Table B-4. Approximation of acute risk to endangered, threatened, and proposed aquatic reptiles in streams, headwaters, or rivers that receive contaminated runoff and drift from program chemicals in Alabama

Endangered, threatened, or proposed species	Indicator species	LC_{50} (mg/L)	1/20 LC_{50} (mg/L)	Representative habitat	EEC (mg/L)	
					Typical	Extreme
Malathion:						
Turtle, Alabama red-bellied	Tadpole (Western chorus frog)	0.2[a]	0.01	Alabama River	0.000168	0.00206
Turtle, flattened musk	Tadpole (Western chorus frog)	0.2	0.01	Alabama River	0.000168	0.00206
Diflubenzuron:						
Turtle, Alabama red-bellied	Channel catfish	370[b]	18.5	Alabama River	0.0000051	0.0000053
Turtle, flattened musk	Channel catfish	370	18.5	Alabama River	0.0000051	0.0000053
Methyl parathion:						
Turtle, Alabama red-bellied	Tadpole (Western chorus frog)	3.7[a]	1.85	Alabama River	0.000263	0.000307
Turtle, flattened musk	Tadpole (Western chorus frog)	3.7	1.85	Alabama River	0.000263	0.000307

[a]Mayer and Ellersieck, 1986.
[b]Julin and Sanders, 1978.
Note: None of the EECs exceeds EPA (1986) risk criterion of 1/20 LC_{50} for endangered aquatic reptile species.

In the aquatic species risk assessment, malathion in runoff posed significant risks to endangered, threatened, and proposed fish. The other program chemicals, diflubenzuron and methyl parathion, posed no risk to fish or other aquatic species, even in extreme scenarios. Eliminating runoff is a difficult task, but the risk may be reduced by avoiding malathion use near sensitive species' habitat. In addition, best crop management practices, such as contour plowing, that decrease runoff will be strongly encouraged. However, in watersheds where a relatively large percentage of the total area is devoted to cotton production, the choice of methyl parathion and diflubenzuron instead of malathion may be appropriate.

Restricting the mode of application and its proximity to sensitive habitat can reduce the effects of pesticide drift on terrestrial and aquatic species. The drift model used to determine insecticide exposures to sensitive species also can be used to determine how close treatments may be applied while preventing a significant concentration of insecticide at the presumed species location. Because ground application methods produce much less drift than aerial methods, they may be permissible in areas where aerial applications are inappropriate.

Another potentially useful protection measure for aquatic species is limiting the total quantity of cotton treated at any one time in a watershed containing known endangered, threatened, and proposed species habitat. This protection measure would reduce the total insecticide concentration in the watershed at any one time and would allow flexibility in choosing the appropriate insecticide. Such flexibility is needed in northern Alabama counties where cotton production constitutes a higher percentage of the total land area than in the remainder of the state. These counties represent only a small fraction of the cotton-producing counties in Alabama; many of them contain endangered, threatened, and proposed species' habitat.

No Effect

***Peromyscus polionotus ammobates*—Alabama beach mouse**

Status. The Alabama beach mouse was listed as endangered on June 6, 1985 (50 FR 23884, June 6, 1985).

Description. A subspecies of the oldfield mouse *(Peromyscus polionotus)*, the Alabama beach mouse has a small body, haired tail, relatively large ears, and protuberant eyes. Its head and body length are 2.7 to 3.4 inches (7 to 9 cm), with a tail length of 1.6 to 2.3 inches (4 to 6 cm). The upper body is pale gray, the sides and underparts are white, and the tail is white with an incomplete dorsal stripe.

Habits. Few life history data are available on this subspecies. However, available data indicate that the Alabama beach mouse feeds mostly on beach grass and sea oats—and on invertebrates, especially in late winter and early spring. The mouse seems to be monogamous as long as both partners remain alive, producing litters about once a month. The litter size ranges from two to seven, averaging about four, with the young reaching reproductive maturity as early as 6 weeks of age. The life span for a related species was estimated at 5 months. The Alabama beach mouse is seminomadic over a relatively small range, digging as many as 20 burrows into the sand dunes for nesting, food storage, and safety refuges from predators (Fish and Wildlife Service, 1987).

Habitat. The Alabama beach mouse is found on coastal dunes from Fort Morgan to Alabama Point in Baldwin County, Alabama. The federally designated critical habitat (effective June 6, 1985) includes three areas: a portion of Fort Morgan State Park, a portion of Bon Secour National Wildlife Refuge, and a portion of Gulf State Park—all in Baldwin County, Alabama.

Factors in Species Decline. This mouse has declined in numbers because of habitat destruction caused by residential and commercial development and tropical storms. Predation by domestic and feral cats may also be a factor (FWS, 1987).

Recovery Plan. The goal of the recovery plan is to downlist the Alabama beach mouse to threatened. This subspecies can be considered for reclassification to threatened when there are three distinct, self-sustaining populations in each critical habitat area and when 50% of the critical habitat is protected and occupied by mice. The achievement of these goals includes protecting existing habitat on publicly owned land and negotiating with private landowners to protect privately owned habitat, including relocating beach trails and building boardwalks. Research will be necessary to determine the subspecies' life history, habitat needs, and genetic variability for translocation purposes. A public information program will help inform citizens about the Alabama beach mouse and the need for sanitation practices around homes, garbage collection, confinement of domestic cats, a feral cat removal program, and beach-monitoring activities. The subspecies may be considered in the future for downlisting to threatened, but because of extensive and permanent habitat loss, it is unlikely that the subspecies can ever be removed entirely from protection (FWS, 1987).

Analysis of Program Impacts. The Alabama beach mouse should not be affected by the boll weevil program because cotton is not grown in or near the coastal dune habitat where the mouse is found. It should not be exposed to any insecticides either directly, from spray drift, or through its food.

Conclusion. No effect.

Peromyscus polionotus trissyllepsis—Perdido Key beach mouse

Status. The Perdido Key beach mouse was listed as endangered on June 6, 1985 (50 FR 23884, June 6, 1985).

Description. A subspecies of the oldfield mouse *(Peromyscus polionotus)*, the Perdido Key beach mouse has a small body, haired tail, relatively large ears, and protuberant eyes. Its head and body length are 2.7 to 3.3 inches (7 to 8 cm), with a tail length of 1.8 to 2.1 inches (4.5 to 5 cm). The upper body is pale grayish fawn to wood brown with a yellowish hue, the sides and underparts are white, and the tail is white to pale grayish brown with no dorsal stripe.

Habits. Few life history data are available on the subspecies. However, available data indicate that the Perdido Key beach mouse feeds mostly on beach grass and sea oats—and on invertebrates, especially in late winter and early spring. This mouse seems to be monogamous as long as both partners remain alive, producing litters about once a month. The litter size ranges from two to seven, averaging about four, with the young reaching reproductive maturity as early as 6 weeks of age. The life span for a related

species was estimated at 5 months. The Perdido Key beach mouse is seminomadic over a relatively small range, digging as many as 20 burrows into the sand dunes for nesting, food storage, and safety refuges from predators.

Habitat. The Perdido Key beach mouse is found on coastal dunes at Gulf Islands National Seashore and Gulf State Park, both on Perdido Key, extending along the Gulf Coast of Baldwin County, Alabama, and Escambia County, Florida. The federally designated critical habitat (effective June 6, 1985) includes three areas: a portion of Perdido Key State Preserve and a portion of Gulf Islands National Seashore—both in Escambia County, Florida—and a portion of Gulf State Park in Baldwin County, Alabama. Because of severe habitat loss following a 1979 hurricane, the Perdido Key beach mouse may be one of the most critically endangered mammals in the United States.

Factors in Species Decline. This mouse population has declined because of habitat destruction caused by residential and commercial development and tropical storms. Predation by domestic and feral cats may have also contributed to the decline (FWS, 1987).

Recovery Plan. The goal of the recovery plan is to downlist the Perdido Key beach mouse to threatened. This subspecies can be considered for reclassification to threatened when there are three distinct, self-sustaining populations in each critical habitat area and when 50% of the critical habitat is protected and occupied by mice (FWS, 1987). The achievement of these goals includes protecting existing habitat on publicly owned land and negotiating with private landowners to protect privately owned habitat, including relocating beach trails and building boardwalks. Research will be necessary to determine the subspecies' life history, habitat needs, and genetic variability for translocation purposes. Finally, the public should be informed about beach mice and their habitat needs, including the need for sanitation practices around homes, increased garbage collection, confinement of domestic cats and a feral cat removal program, and citizen involvement in beach-monitoring activities. The subspecies may be considered in the future for downlisting to threatened, but because of extensive and permanent habitat loss, it is unlikely that the subspecies can ever be removed entirely from protection.

Analysis of Program Impacts. The Perdido Key beach mouse should not be affected by the boll weevil program because cotton is not grown in or near the coastal dune habitat where the mouse is found. It should not be exposed to any insecticides either directly, from spray drift, or through its food.

Conclusion. No effect.

Phaeognathus hubrichti—Red Hills salamander

Status. This species was listed as threatened on January 3, 1977 (41 FR 53034, December 3, 1976).

Description. The Red Hills salamander attains a maximum length of 8.9 inches (225 mm) and is recognizable by its elongated body, short limbs, and prehensile tail. The species is uniformly dark gray to darkish brown (FWS, 1983a).

Habits. Forest arthropods are the common food sources for the Red Hills salamander. Given the abundance of these prey species, competition for food is believed to be unimportant. The reproductive patterns of the Red Hills salamander are unknown. Predation is also unknown, but possible predators include shrews and snakes (FWS, 1983a).

Habitat. The Red Hills salamander prefers rivers or large streams in mesic ravine slopes and bluffsides dominated by hardwood trees. These areas typically have siltstone outcrops and an abundance of arthropods. The species is found only in the Tallahatta and Hatchitigbee formations of Alabama's Red Hills. Currently, an estimated 22,200 acres (9,000 hectares) of habitat remain in this region, including portions of Monroe, Conecuh, Butler, Covington, and Crenshaw Counties (FWS, 1983a).

Factors in Species Decline. The Red Hills salamander is a highly specialized species with low vagility and an apparently low reproductive potential. Consequently, the species is very sensitive to habitat alteration. Major human disturbances, particularly clearcutting forestry operations, pose the greatest threat to the salamander's viability (FWS, 1983a).

Recovery Plan. The ultimate recovery goal is to remove the Red Hills salamander from the endangered and threatened species list. The immediate goal, however, is to prevent the decline to endangered status. The plan includes the assessment of the salamander's preferred habitat (including land use and ownership), the study of population biology and ecology, and the preservation and management of current habitat (FWS, 1983a).

Analysis of Program Impacts. The boll weevil program should not affect the Red Hills salamander. Because the species' preferred habitat occurs in timber stands or regeneration stands along ravines that are too steep for croplands (according to a personal communication with W. Neal), no boll weevil treatments are likely to occur close enough to the species' habitat to affect it or its food sources.

Conclusion. No effect.

Cottus pygmaeus—Pygmy sculpin

Status. The pygmy sculpin was listed as a threatened species on October 30, 1989 (54 FR 39849, September 28, 1989).

Description. The pygmy sculpin rarely exceeds a total length of 1.8 inches (4.6 cm). Its head is large, and its lateral line is incomplete. Although the body coloration varies by sex, maturity, and breeding condition, pigmentation is usually consistent (Williams, 1968; as cited in 54 FR 39849, September 28, 1989). The body pigmentation consists of about three dorsal saddles and mottled or spotted fins. Juveniles possess a grayish-black body with three light-colored saddles, and their heads are black. In adults, the body color becomes lighter, with the grayish-black color forming two dark saddles, and the head becomes white with small, scattered melanophores. During the breeding season, the dark spots on the spinous dorsal fin of males enlarge and become more intense while the fin margin becomes reddish orange. Also, the body becomes suffused with black pigment that nearly conceals the underlying color

pattern. The body color of breeding females is usually slightly darker than in nonbreeding females (54 FR 39849, September 28, 1989).

Habits. The pygmy sculpin prefers spring run areas containing a sand and gravel substrate with large rocks. These areas also contain large mats of vegetation (54 FR 39849, September 28, 1989). No information was available on the pygmy sculpin's dietary habits.

Habitat. The only known population of *C. pygmaeus* occurs in Coldwater Spring and its associated spring run in Calhoun County, Alabama. The spring is impounded to form a 2- to 4-foot-deep pool that covers about an acre (McCaleb et al., 1973; as cited in 54 FR 39849, September 28, 1989). Below the pool, the spring run is as much as 60 feet (18.3 m) wide and 500 feet (152.4 m) long until it joins Dry Creek. Discovered in 1963, the species has never been recorded below the confluence of the spring run and Dry Creek, and it is uncertain whether the historic range of this species was larger in earlier years (54 FR 39849, September 28, 1989).

Factors in Species Decline. Although the City of Anniston, Alabama, owns the entire habitat area and uses Coldwater Spring as its primary water supply, the degradation of water quality in the Coldwater Spring area is the major threat to the pygmy sculpin. Several potential sources of water contamination—including an army depot, an army fort, a chemical manufacturing industry, the City of Anniston, and at least one landfill—lie within the spring's 90 square mile (145 km^2) recharge area. For example, hexavalent chromium from the army depot has been discharged into Dry Creek, and chlorinated hydrocarbons have been found in groundwater at the depot. Although such chemicals have not yet been found in Coldwater Spring, they may be migrating in the local aquifer and thus may present a long-term threat to the species. Another threat to the species is a proposed highway construction project. This construction through the Coldwater Spring recharge area could alter groundwater flow patterns, and any accidental spillage of toxic substances during the construction could contaminate the spring (54 FR 39849, September 28, 1989)

Recovery Plan. None.

Analysis of Program Impacts. The pygmy sculpin's only known habitat area is protected by the Anniston Water Works and Sewer Department, and most of the surrounding land is used for non-agricultural purposes. The cotton acreage in the Coldwater Spring recharge area, if any, is thus relatively minor. Consequently, the species will not be exposed to any of the boll weevil control program insecticides.

Conclusion. No effect.

***Etheostoma nuchale*—Watercress darter**

Status. The watercress darter was listed as endangered on October 13, 1970 (35 FR 16047, October 13, 1970).

Description. This darter's maximum length is 2 inches (5.1 cm). It is recognized by its bulging nape. Breeding males have a red-orange belly as well as red-orange and blue fins; the females have less colorful breeding colors (FWS, 1984a; Ono et al., 1983).

Habits. The species feeds on the aquatic insects, crustaceans, and snails found in thick aquatic vegetation (FWS, 1984j). Females carry ripe eggs from March through July, the approximate period of the male's display of breeding colors. However, little else is known about the reproductive patterns (Ono et al., 1983).

Habitat. Deep, slow-moving backwaters of springs filled with dense growths of aquatic vegetation are the watercress darter's usual habitat. Glenn, Roebuck, and Thomas' Springs in Jefferson County, Alabama, are the only known remaining habitats (FWS, 1984a).

Factors in Species Decline. Habitat alteration and pollution are the major contributors to the watercress darter's decline. Both the Glenn and Roebuck Springs populations have been damaged by high coliform bacteria counts, and sewage from nearby septic tanks is a possible source of the contamination. Also, construction projects in Jefferson County have altered the drainage patterns and, ultimately, the recharge potentials for the three springs (FWS, 1984a).

Recovery Plan. The reclassification of the watercress darter from an endangered to a threatened species is the primary objective of the recovery plan. For reclassification to occur, the long-term protection of the known populations and their habitats must be documented, the populations must be shown to be stable or expanding over a 5-year period, and at least one new population must be established within the historic range (FWS, 1984a).

Analysis of Program Impacts. Jefferson County, Alabama, is not a cotton-producing county.

Conclusion. No effect.

Phyllitis scolopendrium var. *americana*—American hart's-tongue fern

(The FWS recognizes *Phyllitis japonica* Kom. ssp. *americana* Love and Love as equivalent to *Phyllitis scolopendrium* var. *americana*.)

Status. The American hart's-tongue fern was listed as threatened on July 14, 1989 (54 FR 29730, July 14, 1989).

Description. The American hart's-tongue fern has evergreen, strap-shaped fronds that are 5 to 17 inches long. The green petiole is 1 to 5 inches long and covered with cinnamon scales. Sori are linear and occur on the underside of the frond.

Habits. The fronds arise in a cluster from a short creeping rhizome.

Habitat. The fern is usually found growing on or near dolomitic limestone. The fern appears to prefer moist soil, shade, and high humidity. The species is found in Jackson and Morgan Counties in Alabama. These populations are associated with caves or sinkholes. The Fish and Wildlife Service's "Counties of Occurrence" list shows this species to be present only in Morgan County, Alabama.

Factors in Species Decline. The fern is threatened throughout most of its range by trampling, habitat

alteration, or destruction of habitat by logging, residential development, or quarrying.

Recovery Plan. None.

Analysis of Program Impacts. Although the American hart's-tongue fern is located in a cotton-producing county, the species will not be directly or indirectly affected by the boll weevil control program because it reproduces by spores, a form of reproduction that does not require insect pollinators.

Conclusion. No effect.

Sarracenia rubra ssp. *alabamensis*—Alabama canebrake pitcher-plant

Status. The Alabama canebrake pitcher-plant was listed as endangered on April 10, 1989 (54 FR 10154, March 10, 1989).

Description. This species is a carnivorous herb of the pitcher-plant family (*Sarraceniaceae*). This species produces two types of pitchers, or hollow leaves, each year. Spring pitchers appear with the maroon flowers. Summer pitchers are larger, distinctively shaped, puberulent, yellow-green, and inconspicuously veined and aeroluate in the upper portion. The fruit of the plant is a capsule.

Habits. The plant flowers from late April to early June.

Habitat. The species occurs in sandhill seeps, swamps, and bogs along the fall line of central Alabama. Soils are acidic, highly saturated, and peaty sand or clay. The species is endemic to Autauga, Chilton, and Elmore Counties in central Alabama.

Factors in Species Decline. Population decline of this species has been the result of habitat destruction, succession due to inhibition of fire, overcollecting, and adverse land-use practices. Increased agricultural use of the area has resulted in draining of some of the species habitat.

Recovery Plan. None.

Analysis of Program Impacts. Because the lands adjacent to Alabama canebrake pitcher-plant habitat are currently used for pasture, the boll weevil control program would not affect this species. If the adjacent pasture lands are converted to cotton production, however, consultation will be initiated, if necessary.

Conclusion. No effect.

Sarracenia oreophila—Green pitcher-plant

Status. The green pitcher-plant was listed as endangered on October 21, 1979 (44 FR 54923, September 21, 1979; 45 FR 18929, March 24, 1980).

Description. The green pitcher-plant is a perennial herb with moderately branched rhizomes. The pitcher leaves ascend with the flower buds and mature from late April through May. The pitcher leaves are yellow-green with maroon veining and a hood over the opening. The pitcher

leaves wither by midsummer and are replaced by flat, falcate leaves. The yellow flowers occur singly on scapes.

Habits. The pitcher-plant is pollinated by bees. It is insectivorous, and a number of insect species have co-evolved with it. It flowers from late April through May.

Habitat. The green pitcher-plant may grow in three habitat types. It can be found in mixed-oak flatwoods where there is flat relief and poor drainage. Another habitat is seepage bogs or areas with boggy spring heads. These bog areas have variable-canopy vegetation. The third habitat is sandstone stream banks or sandy, rocky banks. This is the only *Sarracenia* species found outside the Coastal Plain. It is found only in Cherokee, Dekalb, Etowah, Jackson, and Marshall Counties in Alabama.

Factors in Species Decline. Degradation of populations and habitats have resulted from increased urban and agricultural development. Commercial and amateur collecting also have contributed to its decline. Other colonies have been lost to floods and streambank erosion (FWS, 1985a).

Recovery Plan. The primary objective of the recovery plan is to delist the green pitcher-plant as an endangered species. Actions toward this goal include protecting existing colonies from taking, reestablishing colonies at extirpated sites, and increasing public education. The species will be considered recovered when 15 colonies are protected and managed to ensure their continued existence (FWS, 1985a).

Analysis of Program Impacts. Although the green pitcher-plant is located in cotton-producing counties, it is unlikely to be directly or indirectly affected by the boll weevil control program because it is presently restricted to seepage bogs and flatwoods, areas that are not conducive to cotton production.

Conclusion. No effect.

***Lesquerella lyrata*—Lyrate bladder-pod**

Status. The lyrate bladder-pod was proposed for listing as a threatened species on April 25, 1990 (55 FR 17552, April 25, 1990).

Description. The lyrate bladder-pod is an annual that ranges from 4 to 12 inches (10 to 30 cm) in height. Plants are shortly pubescent and usually branched near the base. The stem leaves are alternate, oval to elliptic in shape, smooth or toothed on the margins, with prominent ear-like projections at the bases. The flowers are ascending, on stalks 0.39 to 0.59 inches (10 to 15 mm) long, with yellow petals 0.2 to 0.26 inches (5 to 7 mm) in length. The fruits are siliques, globose in shape, 0.1 to 0.14 inches (2.5 to 3.5 mm) long and 0.12 to 0.16 inches (3 to 4 mm) wide (Rollins and Shaw, 1973; McDaniel, 1987; both as cited in 55 FR 17552, April 25, 1990).

Habits. The lyrate bladder-pod flowers from March to April, bears fruit during this time, and disperses seeds in late April or May. It is dormant in the summer, surviving as seeds, germinates in the fall, and overwinters as a rosette (J. Baskin, 1989; as cited in 55 FR 17552, April 25, 1990).

Habitat. The lyrate bladder-pod is a component of glade flora and occurs in association with limestone outcroppings. The terms "glade" and "cedar glade" refer to shallow-soiled open areas that are sometimes surrounded by cedar woods. Under natural conditions, the plant is an early successional species that colonizes shallow cedar glade soils and then slowly disappears as the soil layer further develops. This species is a poor competitor and is eliminated by shade and competition from invading perennials. Because of the continuing loss of cedar glades in its native habitat range, the presently available habitat for the plant is limited to areas modified by human activity. Periodic disturbance of the soil arrests succession and brings seeds to the surface, which facilitates germination (Baskin, 1989; Webb and Lyons, 1984; both as cited in 55 FR 17552, April 25, 1990). The two known remaining populations of the species occur in Franklin and Colbert Counties, Alabama. These two populations are located primarily on gladelike areas that exhibit various degrees of disturbance, including unimproved pastures, cultivated and plowed fields, and roadside rights-of-way (55 FR 17552, April 25, 1990).

Factors in Species Decline. The cedar glade systems in Alabama have been and continue to be modified by agricultural development, housing development, and garbage dumping (Kral, 1983; as cited in 55 FR 17552, April 25, 1990). Although periodic disturbances from the plowing of row crops are helpful in maintaining populations of *L. lyrata*, plowing or herbicide use during the spring before seed set and dispersal may affect the species. Although populations located in pastures may be enhanced by light grazing, heavy grazing causes excessive soil compaction that may affect the plant. Because the species has only a limited range and only a few surviving populations, the greatest threat to the species is its extreme vulnerability to further habitat modification (55 FR 17552, April 25, 1990).

Recovery Plan. None.

Analysis of Program Impacts. The flowering stage of the lyrate bladder-pod's life cycle occurs before the initiation of insecticide use in the Alabama control program, and the species is dormant during the summer. Consequently, it is unlikely that the program will have any direct effects on the species or any indirect effects through the temporary reduction of insect pollinators.

Conclusion. No effect.

Apios priceana—Price's potato-bean

Status. Price's potato-bean was listed as a threatened species on February 5, 1990 (55 FR 433, January 5, 1990).

Description. *Apios priceana* is a twining perennial vine which climbs up to 5 meters from a single, large thickened tuber. Leaves are alternate, pinnately compound with five to seven leaflets that are ovate lancolate to broadly ovate in shape and glabrous to short-hairy beneath. The flowers are borne in the leaf axils and consist of peduncled racemes or compact pinnacles, 2 to 6 inches (5 to 15 cm) long. Individual flowers are about 0.75 inches (2 cm) long and are greenish white tinged with purplish pink toward the tip (55 FR 433, January 5, 1990).

Habits. Flowering occurs from mid-June through August, with fruits present from late August through September (Kral, 1983; Medley, 1980; Woods, 1988; all as cited in 55 FR 433, January 5, 1990).

Habitat. Price's potato-bean occurs in the open areas of mixed hardwood forests and is commonly associated with *Quercus muhlenbergii*, *Lindera benzoin*, *Campanula americana*, *Arundinaria gigantea*, *Tilia americana*, *Fraxinus americana*, *Acer saccharum*, *Ulmus rubra*, *Cerciscanadensis*, and *Parthenocissus guinguefolius* (Medley, 1980; as cited in 55 FR 433, January 5, 1990). Also, populations occur in open woods and along wood edges in limestone areas, often where river bluffs grade into creek or river bottoms (Kral, 1983; Medley, 1980; both as cited in 55 FR 433, January 5, 1990). Populations may extend onto roadside or power line rights-of-way. Soils are described as well-drained loams on old alluvium or over limestone (Kral, 1983; as cited in 55 FR 433, January 5, 1990). Currently, this species is known to exist at only 13 sites with populations in Alabama, Kentucky, Mississippi, and Tennessee. Alabama has two populations of 15 to 30 individuals located in Madison County and Autauga County, respectively. A third population of less than five individuals exists in Marshall County (Medley, 1980; as cited in 55 FR 433, January 5, 1990).

Factors in Species Decline. *Apios priceana* is currently or potentially jeopardized by habitat modification, including cattle grazing and trampling, clearcutting, excessive shading and competition from weeds during succession, and the use of herbicides in roadsides or power line rights-of-way maintenance (55 FR 433, January 5, 1990).

Recovery Plan. None.

Analysis of Program Impacts. Although the species occurs in cotton-growing counties, Price's potato-bean's preferred habitat of open woods does not support cotton production. Therefore, it is unlikely that any control program activities will adversely affect the species. However, some habitat areas lie adjacent to cattle grazing areas; and if these grazing lands are converted to cotton production, consultation will be initiated, if necessary.

Conclusion. No effect.

Dalea foliosa—Leafy prairie-clover

Status. The leafy prairie-clover was proposed for listing as an endangered species on March 27, 1990 (55 FR 11230, March 27, 1990).

Description. The leafy prairie-clover is a perennial whose stems stands approximately 20 inches (0.5 m) tall above a hardened root crown. The plant's pinnately compound alternate leaves are 1.4 to 1.8 inches (3.5 to 4.5 cm) long and are composed of 20 to 30 leaflets. Small purple flowers are borne in dense spikes at the end of the stems (Smith and Wofford, 1980; as cited in 55 FR 11230, March 27, 1990).

Habits. Flowering begins in late July and continues through August. Seeds ripen by early October, and the aboveground portion of the plant dies soon afterward. The dead stems remain erect and disperse ripened seeds from late fall to early spring (Baskin and Baskin, 1973; as cited in 55 FR 11230, March 27, 1990).

Habitat. The leafy prairie-clover is typically found growing in close association with the cedar glades of central Tennessee and northern Alabama. However, the species apparently prefers the deeper soil of the prairie-like areas along the boundaries of and within the rocky cedar glades of the region (Smith and Wofford, 1980; as cited in 55 FR 11230, March 27, 1990). In Alabama, one population is known to exist in Morgan County.

Factors in Species Decline. In general, the leafy prairie-clover is threatened throughout its range by habitat alteration, including residential, industrial, and commercial development, livestock grazing, and the conversion of land to pasture areas. In addition to these factors, the leafy prairie-clover is threatened by the encroachment of more competitive herbaceous vegetation and woody plants and the drought in the species' habitat during the past 3 years (1987-89). It is believed that this lack of moisture is a factor in the species' low reproductive rate (55 FR 11230, March 27, 1990).

Recovery Plan. None.

Analysis of Program Impacts. Only Rutherford County in Tennessee and Morgan County in Alabama are cotton-producing counties containing populations of the leafy prairie-clover. However, the program will have no effect on the species because the Tennessee population is located in a state park and the Alabama population is adjacent to livestock grazing areas (55 FR 11230, March 27, 1990). If the grazing areas are converted to cotton production, consultation will be initiated, if necessary.

Conclusion. No effect.

Amphianthus pusillus—Little amphianthus

Status. Little amphianthus was listed as threatened on March 7, 1988 (53 FR 3565, February 5, 1989).

Description. Little amphianthus is a small fibrous-rooted annual of the snapdragon family. The plant has dimorphic leaves and flowers. Submerged leaves are lanceolate and in a basal rosette. Floating leaves are ovate with long delicate stems. The flowers are white and 0.01 inches (4 mm) wide. Floating flowers are open and submerged flowers are closed. The fruit is a capsule.

Habits. Little amphianthus flowers in March or April. It is ephemeral and completes its life cycle in 3 to 4 weeks. Its population size and vigor depend on moisture. Little is know about its pollinators.

Habitat. This species is found in pools surrounded by a rock rim in sandy-silty soils. It is endemic to granite outcrops in the Piedmont physiographic region. It prefers large isolated domes or gently rolling flatrocks. These areas usually have high light intensities and extreme wet and dry periods. The Fish and Wildlife Service's "Counties of Occurrence" list shows this plant is present in Chambers and Randolph Counties, Alabama.

Factors in Species Decline. Little amphianthus has declined because of habitat destruction caused by quarrying and eutrophication of pools from cattle and recreation.

Recovery Plan. None.

Analysis of Program Impacts. Although the little amphianthus is located in cotton-producing areas, the species' flowering period does not correspond with the insecticide treatment periods scheduled for the control program. For this reason, the program will have no direct effects on the species or any indirect effects through the temporary reduction of insect pollinators.

Conclusion. No effect.

May Affect

Myotis grisescens—Gray bat

Status. The gray bat was listed as endangered on April 28, 1976 (41 FR 17740, April 28, 1976).

Description. The gray bat is the largest member of its genus in the eastern United States. Its forearm measures 1.5 to 1.8 inches (40 to 46 mm), and it weighs from 0.3 to 1 ounce (7 to 16 g). It is easily distinguished from all other bats within its range by its unicolored dorsal fur, because all other eastern bats have distinctly bi- or tricolored fur on their backs. Following molt in June or July, gray bats are dark gray, but they often bleach to chestnut brown or russet between molts, especially reproductive females during May and June. The wing membrane connects to the foot at the ankle rather than at the base of the first toe, as in other species of *Myotis* (FWS, 1982a).

Habits. Gray bats feed on insects. During peak insect abundance in early evening, many gray bats feed in slowly traveling groups, but when insect activity subsides 1 to 2 hours after sundown, the bats become territorial. Depending on prey abundance, foraging territories may be occupied by from 1 to as many as 15 or more bats. Territories seem to be controlled by reproductive females and are located in the same places and used by the same individual bats from one year to the next. Most migrate seasonally between hibernating caves and maternity caves. On arrival at hibernating caves, the adults mate, and the females immediately begin hibernation, some as early as the first of September and nearly all by early October. Following mating, the males remain active for several weeks, during which time fat supplies depleted during breeding are replenished. The juveniles of both sexes and adult males tend to enter hibernation several weeks later than the adult females, but most are in hibernation by early November. Stored fat reserves must last for at least 6 to 7 months. The adult females store sperm throughout the winter months and become pregnant soon after they emerge from hibernation. The adult females emerge in late March or early April, followed by the juveniles of both sexes and the adult males. Migration is hazardous, especially in spring when fat reserves and food supplies are low. Consequently, adult mortality is especially high in late March and in April. The pregnant females give birth to a single young in late May or early June. At that time, the reproductively active females congregate in a single, traditional maternity cave (usually the warmest one available), while males and nonreproductive females congregate in smaller groups in more peripheral caves within the colony home range. Most young begin to fly 20 to 25 days after birth. Each summer colony occupies a traditional home range that often contains several roosting caves scattered along as much as 43.5 miles (70 km) of river or reservoir borders. Colony members are

extremely loyal to their colony home range, but they tend to disperse in groups among several different caves within that area.

Habitat. Most winter caves are deep and vertical; all provide large volume below the lowest entrance and act as cold air traps. A much wider variety of cave types are used during the spring and fall transient periods. In summer, maternity colonies prefer caves that act as warm air traps or that provide restricted rooms or domed ceilings that are capable of trapping the combined body heat from thousands of clustered individuals. During all seasons, males and yearling females seem less restricted to specific cave and roof types. Summer caves, especially those used by maternity colonies, are nearly always located within a kilometer of the rivers or reservoirs over which the bats feed. Newly volant young gray bats often feed and take shelter in the forest surrounding the cave entrances. Forested areas surrounding caves and between caves and overwater feeding habitat clearly are advantageous to gray bat survival. The bat is found in limestone karst areas of the Southeast—in Alabama, Arkansas, Missouri, Florida, and Tennessee. There is no federally designated critical habitat for the gray bat. Important habitats in Alabama are Fern and Sauta Caves in Jackson County, Cave Springs Cave in Morgan County, Key Cave in Lauderdale County, Georgetown Cave in Colbert County, Hambrick Cave in Marshall County, and Sanders Cave in Conecuh County. The Fish and Wildlife Service's "Counties of Occurrence" list includes 11 counties in Alabama.

Factors in Species Decline. The reasons for the gray bat decline include human disturbance (entrance into caves during hibernation), environmental disturbance (pesticide use, chemical pollution, siltation of waterways over which gray bats forage, and deforestation leading to increased predation), impoundment of waterways, cave commercialization, improper gating, and natural calamities (cave flooding and cave-ins) (FWS, 1982a).

Recovery Plan. The objective of the recovery plan is to remove the gray bat from endangered status (FWS, 1982a). The criteria for change from endangered to threatened status are documentation of protection of 90% of the Priority 1 hibernacula and documentation of stable or increasing populations at 75% of Priority 1 maternity caves during a period of 5 years. Once the status has been changed from "endangered" to "threatened," it will be possible to delist this species by the documentation of permanent protection as well as stable or increasing populations during 5 years of 25% of Priority 2 caves in each state. The most important feature of this plan is protecting the roosting habitat, but it also includes maintaining, protecting, and restoring the forage habitat and monitoring population trends.

Analysis of Program Impacts. Because they roost in caves during the day and foraging is crepuscular and nocturnal, direct toxic insecticide exposures of gray bats are not likely to occur. Depletion of their insect food supplies could be a problem only if accidental overspraying or significant drift of insecticides occurred during applications to cotton fields next to the streams, rivers, and lakes where the bats are known to forage. In known foraging areas, risks will be decreased by avoiding aerial applications within 200 feet (61 m) of identified riparian areas. Within this buffer, only ground equipment will be

used. Bat colonies roosting in caves could be disturbed by aircraft overflights. To prevent this disturbance, aircraft overflights of identified roosting caves will be avoided. Although direct exposure to malathion or methyl parathion may present a risk to the species, such occurrences are extremely unlikely because the bats spend most of the daylight hours roosting in caves.

Conclusion. May affect.

***Myotis sodalis*—Indiana bat**

Status. The Indiana bat was listed as endangered on March 11, 1967 (32 FR 4001, March 11, 1967).

Description. The Indiana bat is small, with a forearm length of 1.4 to 1.6 inches (35 to 41 mm) and a head and body length of 1.6 to 1.9 inches (41 to 49 mm). It is grayish brown in color, with grayish ears and membranes. It has a keeled calcar and small, delicate hindfeet with short hairs. The young are usually capable of flight within a month of birth.

Habits. Indiana bats seem to feed primarily on *Lepidoptera* and aquatic insects. Most Indiana bats migrate seasonally between winter and summer roosts. On arrival at hibernating caves, swarming occurs, which is described as "a phenomenon in which large numbers of bats fly in and out of cave entrances from dusk to dawn, while relatively few roost in the caves during the day" (Cope and Humphrey, 1977; as cited in FWS, 1983b). Swarming may continue for several weeks. Fat supplies are replenished before hibernation. The males tend to remain active longer at cave entrances during the swarming period than females (LaVal and LaVal, 1980; as cited in FWS, 1983b). After the bats mate, the females enter directly into hibernation, some as early as October. Nearly all the males are hibernating by late November. They usually hibernate in large, dense clusters of about 300 bats per square foot. Presumably, the adult females store sperm through the winter and become pregnant soon after emergence from hibernation. The females emerge in late March or early April, followed by the males. The females give birth to a single young in June or July, at which time they join together in nursery colonies beneath the loose bark of trees. Known maternity colonies occur in riparian habitats, although recent evidence suggests that colonies may also occur in upland habitats. Little is known of the roosting habits of the males, but scattered reports indicate that they disperse throughout the range in summer. The latter part of the summer is spent accumulating fat reserves for fall migration and hibernation.

Habitat. For winter hibernation, Indiana bats require specific roost sites in caves or mines that have stable temperatures below 50°F (10°C), preferably from 39.2 to 46.4°F (4 to 8°C). Only a small percentage of available caves provide the stable low temperatures that allow the bats to maintain a low rate of metabolism and conserve fat reserves until spring (Humphrey, 1978; as cited in FWS, 1983b). Little is known about Indiana bat summer habitat. Recent studies have indicated that maternity colonies are formed mostly in riparian and floodplain areas of small- to medium-sized streams. These bats have also been found in tree-lined drainage ditches and forests. Optimum foraging habitat seems to consist of streams lined on both sides with

mature trees that overhang the water by more than 9.8 feet (3 m).

Critical habitats for the Indiana bat are Blackball Mine in LaSalle County, Illinois; Big Wyandotte Cave in Crawford County and Ray's Cave in Greene County, Indiana; Bat Cave in Carter County and Coach Cave in Edmonson County, Kentucky; Cave 201 in Crawford County, Cave 009 and Cave 017 in Franklin County, Pilot Knob Mine in Iron County, Bat Cave in Shannon County, and Cave 029 in Washington County, Missouri; White Oak Blowhole Cave in Blount County, Tennessee; and Hellhole Cave in Pendleton County, West Virginia. Important habitats in the program area are Fern, Sauta, and Nitre Caves in Jackson County, Alabama. The Fish and Wildlife Service's "Counties of Occurrence" list includes 11 counties in Alabama.

Factors in Species Decline. The Indiana bat populations have declined because of natural and human hazards. The natural hazards include the flooding of caves, collapsing of cave ceilings, and dying from freezing in severe winters. Human causes include disturbance (arousal during hibernation causes them to use a significant portion of their fat reserves, making it likely they will leave the cave too soon and die); vandalism (bats often are misunderstood and viewed by many people with fear and repugnance); deforestation; stream channelization without accompanying restoration of riparian forest cover; indiscriminate collecting, handling, and banding of hibernating bats; commercialization of hibernacula; exclusion of bats from caves by poorly designed gates; changes in cave microclimate through the opening of additional entrances or the blocking of air flow by poorly designed gates; and flooding of caves by reservoirs (FWS, 1983b).

Recovery Plan. The objective of the recovery plan is to remove the Indiana bat from endangered status (FWS, 1983b). The most important feature of this plan is to gain control of important hibernacula and protect them from human disturbance. Other features include maintaining, protecting, and restoring foraging and nursery habitat; monitoring population trends; public education; and filling research needs to increase management efficiency. Actions to achieve these objectives include erecting warning signs, gating or fencing the caves, monitoring hibernacula, monitoring caves by law enforcement agencies, discouraging human access, preventing adverse modifications to and rehabilitating the subsurface, preventing adverse modifications to and rehabilitating the surface watershed surrounding important roost sites, making locations of hibernacula available to appropriate Fish and Wildlife Service officials and state wildlife agencies, identifying all Indiana bat winter and fall roost sites, evaluating roost sites, identifying roost sites to be protected, determining habitat requirements, preserving water quality, restoring and preserving forest cover along rivers and streams, monitoring habitat, monitoring status of populations in hibernacula, monitoring status of populations in summer, and monitoring residues of toxic chemicals in insects and bats.

Analysis of Program Impacts. Direct toxic effects to Indiana bats could occur from a direct spraying of malathion or methyl parathion. Depletion of the bat's food supplies could occur in riparian areas if accidental overspraying or drift were to occur. In known foraging areas, risks will be

decreased by avoiding aerial applications within 200 feet (61 m) of identified riparian areas. Within this buffer, only ground equipment will be used. Roosting bat colonies could be disturbed by aircraft overflights. To prevent this disturbance, aircraft overflights of identified roosting areas will be avoided.

Conclusion. May affect.

***Charadrius melodus*—Piping plover**

Status. The Great Lakes watershed population of the piping plover was listed as endangered on January 10, 1986 (50 FR 50733, December 11, 1985). The Atlantic Coast and northern Great Plains populations were listed as threatened on January 10, 1986 (50 FR 50733, December 11, 1985).

Description. The adult piping plovers have a sand-colored body, white undersides, and orange legs. A white wing stripe and white rump are visible during flight. During the breeding season, the adults acquire a black forehead and breast bands. Juvenile plumage is similar to that of the nonbreeding adults. These birds are about 6.7 inches (17 cm) long and weigh 1.6 to 2.4 ounces (45 to 64 g).

Habits. Piping plovers are migratory shorebirds. They arrive in their northern breeding grounds in April or May. Eggs are usually laid in the second or third week of May in a cup nest in the sand, lined with pebbles or shell fragments. Four is the usual clutch size. Chicks are precocial, and the plover leaves the nesting grounds in August. The usual diet consists of marine worms, crustaceans, insects, and mollusks.

Habitat. Nesting occurs in sandflats, saline or alkaline wetlands, and sandbars in the northern plains of Montana, North Dakota, South Dakota, and Nebraska. Piping plovers winter in Mobile and Baldwin Counties, Alabama (FWS, 1988).

Factors in Species Decline. The piping plover's natural habitat is quite ephemeral. Thus, the species is susceptible to nest destruction and, ultimately, population fluctuations. In addition to this natural loss, sandy beaches have been destroyed as habitat areas by recreational and commercial development. The piping plover is easily disrupted by human disturbances. Hunting also led to a decline in the species in the 19th and early 20th centuries.

Recovery Plan. The goal of the Atlantic Coast Piping Plover Recovery Plan is to double the size of the Atlantic coast population. Steps toward this goal will include managing populations and breeding habitat to maximize productivity, monitoring and managing wintering areas, and further investigating the species' biology (FWS, 1988).

Analysis of Program Impacts. According to the results of the terrestrial wildlife risk assessment, direct exposure to methyl parathion may present a risk to the piping plover. However, the species should not be at risk from insecticide use in the boll weevil program because its habitat preference and feeding habits are not in any way associated with cotton production. The piping plover's migratory and habitat requirements make direct exposure extremely unlikely. But because individual birds may migrate through cotton-producing areas, preference will be given to the use

of malathion or diflubenzuron in the identified migratory corridor during the migration period.

Conclusion. May affect.

***Haliaeetus leucocephalus*—Bald eagle**

Status. The bald eagle was listed as endangered throughout the lower 48 States on March 11, 1967 (32 FR 4001, March 11, 1967). The species was reclassified as threatened in Washington, Oregon, Minnesota, Wisconsin, and Michigan on March 16, 1978 (43 FR 6233, February 14, 1978).

Description. The bald eagle is a large raptor, 30 to 35 inches (76 to 89 cm) long, with a wingspan of 7 feet (2.1 m) and a weight of 8 to 13 pounds (3.6 to 5.9 kg). Adult eagles are dark brown with a white head and tail, and immature eagles are dark brown over their entire bodies (FWS, 1984b).

Habits. Bald eagles generally mate for life, and breeding starts at age 4 or 5. Eagles are territorial during the breeding season; they defend an average territory size of 57 acres (23 hectares) and establish a platform nest of sticks in a tall tree or on a cliff. A female bald eagle lays two eggs; incubation time is usually 35 days; and 10 to 12 weeks are needed for fledging. Bald eagles are opportunistic feeders, and they eat a variety of prey, both living and carrion. Their preferred diet is fish (FWS, 1984b).

Habitat. Bald eagles are found in riparian habitats—rivers, coasts, and lakes. Nesting sites are usually within a half mile of water, in the largest living tree in a stand, and with an open view of the surrounding area (FWS, 1984b). The Fish and Wildlife Service's "Counties of Occurrence" list includes 11 counties in Alabama.

Factors in Species Decline. Reasons for the eagle's decline include lowered reproductive success because of pesticide residues, loss of habitat, and human disturbances, particularly wanton shooting (FWS, 1984b).

Recovery Plan. The primary objective of the Southeastern States Recovery Plan is to remove the bald eagle from the endangered and threatened list by protecting and managing eagle populations and habitat and improving public support for the recovery plan (FWS, 1984b).

Analysis of Program Impacts. Based on the terrestrial wildlife risk assessment, direct exposure to methyl parathion may present a risk to the bald eagle. However, the other two boll weevil control program insecticides do not present an unreasonable risk to the species. Consequently, the species can be protected by using only malathion or diflubenzuron in known eagle foraging areas. Direct exposure risks can be reduced by avoiding the use of methyl parathion in areas where active nests or roosts are known. Also, disturbance of the species' nests or roosting sites by program activities can be prevented by avoiding overflights and program activities within 300 feet of known nests or roosting sites.

Conclusion. May affect.

***Picoides* (=*Dendrocopos*) *borealis*—Red-cockaded woodpecker**

Status. The red-cockaded woodpecker was listed as endangered on October 13, 1970 (35 FR 16047, October 13, 1970).

Description. The red-cockaded woodpecker is small, 7 to 8 inches (18 to 20 cm) long. It has black and white horizontal stripes on its back, white cheeks, and a black cap. In addition, the male has a small red spot on its cheeks (FWS, 1985b).

Habits. This woodpecker builds its nest in an excavated cavity in living pine trees usually infected by red heart disease. These birds are strongly territorial and keep numerous small "wells" of sap running as a cavity defense mechanism. The birds live in a family unit, or clan, of 5 to 10 birds, consisting of a breeding pair and unmated young.

Habitat. The red-cockaded woodpecker is a habitat specialist, nesting in open stands of pines a minimum of 60 years old. A clan requires an average of 200 acres (81 hectares). Currently, the red-cockaded woodpecker is found in 12 states throughout the southeastern and midsouthern United States, and an estimated 2,700 colonies nest on federally owned land.

Factors in Species Decline. The decline of the red-cockaded woodpecker has been facilitated by the loss of habitat and forestry practices that destroy the old-growth pine forests preferred by the species.

Recovery Plan. The ultimate objective of the recovery plan is to maintain viable populations in all physiographic regions and forest types where the species is known to occur. According to the plan, all forests with adequate acreage should sustain minimum populations of 250 clans, while smaller properties should maintain populations for the highest sustainable densities (FWS, 1985b).

Analysis of Program Impacts. Because the red-cockaded woodpecker establishes colonies and forages in old-growth pine stands, the species should not be exposed to any of the boll weevil control program insecticides. Although direct exposure to malathion or methyl parathion may present an unacceptable risk to the woodpecker, the species habitat requirements make such an occurrence unlikely. However, in the instance where a nest or colony is established in a pine stand adjacent to a cotton field, the potential risk to the species will be lessened by avoiding aerial applications within 200 feet (61 m) of the colony or nest. Within this buffer, only ground equipment will be used.

Conclusion. May affect.

***Gopherus polyphemus*—Gopher tortoise**

Status. The gopher tortoise was listed as threatened on August 6, 1987, for all areas west of the Mobile and Tombigbee Rivers in Alabama, Mississippi, and Louisiana (52 FR 25380, July 7, 1987).

Description. The gopher tortoise has a large, dark-brown to grayish-black shell that is generally 5.9 to 14.6 inches

(15 to 37 cm) in length. A terrestrial turtle, the species has elephantine hind feet and shovel-like forefeet. A gular projection exists below the head of the yellowish, hingeless plastron (Ernst and Barbour, 1972; as cited in 52 FR 25380, July 7, 1987).

Habits. The females reach sexual maturity after 13 to 21 years, and an average of five to eight eggs per clutch is expected when nesting occurs (52 FR 25380, July 7, 1987).

Habitat. Well-drained, sandy soils in transitional areas of forest and grass are the preferred habitat areas for the gopher tortoise (Ernst and Barbour, 1972; as cited in 52 FR 25380, July 7, 1987). The species is usually found where a pine overstory and an open understory with grass and forb ground cover allow ample sunlight to penetrate nesting areas (Landers, 1980; as cited in 52 FR 25380, July 7, 1987). Overall, the gopher tortoise is now found in coastal plain areas of South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana (52 FR 25380, July 7, 1987). The Fish and Wildlife Service's "Counties of Occurrence" list includes Choctow, Mobile, and Washington Counties, Alabama.

Factors in Species Decline. The gopher tortoise's historical range west of the Mobile and Tombigbee Rivers has been significantly reduced by the loss of coastal plain habitat. Urban, crop land, and pasture land developments have destroyed nesting areas and isolated populations. Habitat fragmentation has increased road mortality. The forest management practices of fire suppression and clearcutting have also affected the species. Periodic burning or thinning of forest stands is necessary to maintain an open understory and, consequently, the grasses, forbs, and sunny nesting areas preferred by the species. The suppression of wildfires facilitates forest succession and the closing of the understory. Ultimately, the growth of thick underbrush destroys preferred food plants, inhibits nesting, and forces the gopher tortoise to exposed, marginal areas along the edge of the habitat. Clearcutting similarly forces individuals to the habitat's edge, where chances of roadside mortality or human predation are greatest (52 FR 25380, July 7, 1987).

Recovery Plan. None.

Analysis of Program Impacts. The gopher tortoise's thick carapace and leathery skin should limit any dermal exposure to the boll weevil control program insecticides. The only circumstance that would present a risk to the gopher tortoise would be if the tortoise fed on a large quantity of vegetation immediately after the vegetation had been directly sprayed with insecticide. This scenario is unlikely, but possible, in those areas where cotton is grown immediately adjacent to gopher tortoise foraging habitat. Furthermore, the terrestrial wildlife risk assessment indicates that direct exposure to methyl parathion presents an unacceptable risk to the gopher tortoise. To protect the tortoise from the risk of indirect exposure from the consumption of vegetation sprayed with insecticide, APHIS will avoid the use of methyl parathion in cotton fields adjacent to known gopher tortoise foraging areas in cotton fields in Choctaw, Mobile, and Washington Counties, Alabama. Also, aerial application of malathion and diflubenzuron will be avoided within 200 feet of known foraging areas. Within this buffer, only ground equipment will be used.

Conclusion. May affect.

Pseudemys alabamensis—Alabama red-bellied turtle

Status. The Alabama red-bellied turtle was listed as endangered on July 16, 1987 (52 FR 22943, June 16, 1987).

Description. The Alabama red-bellied turtle has a large, highly arched carapace that is usually 8 to 10 inches (20.3 to 25.4 cm) long. The carapace is brown to olive with yellow, orange, or reddish streaks and light, vertical bars on the pleural scutes. The turtle's skin is olive to black with yellow-to-light-orange stripes; the plastron is orange red. Other identifying features include a prominent notch at the tip of the upper jaw, bordered on each side by a toothlike cusp (52 FR 22943, June 16, 1987).

Habits. A heliothermic, herbivorous species, the red-bellied turtle often takes refuge in beds of aquatic vegetation, which provides the species with a refuge from predation where the turtle may safely bask and locate food (Dobie, 1985; as cited in 52 FR 22943, June 16, 1987). The species probably nests repeatedly in only one area (52 FR 22943, June 16, 1987).

Habitat. The backwater areas of fresh water bays, usually 3.3 to 6.6 feet deep, with dense growths of submerged and emergent aquatic vegetation, are the preferred habitat of the red-bellied turtle. The lower floodplain of the Mobile River system in Baldwin and Mobile Counties, Alabama, is the current habitat. However, only one known nesting site still exists within this habitat range (52 FR 22943, June 16, 1987).

Factors in Species Decline. The historic range of the red-bellied turtle once extended as far north as Monroe County, Alabama. However, heavy recreational use of the preferred nesting grounds has reduced the distribution and size of the population. During the summer nesting period, campers frequent the nesting beaches, and the lights, people, and noise discourage or prevent the turtles from laying eggs. Offroad vehicles may trample nests and uncover eggs, exposing them to egg breakage, dehydration, or predation (B. Weisberger, personal communication to Fred M. Bagles; as cited in 52 FR 22943, June 16, 1987). The fish crow (*Corvus ossifragus*) preys heavily on red-bellied turtle eggs, seriously limiting the reproductive success in the only nesting area. Human predation is an additional concern; local residents have been known to gather the eggs for food, while collectors and poachers have sold the turtles as pets and food (52 FR 22943, June 16, 1987).

Recovery Plan. None.

Analysis of Program Impacts. The results of the aquatic species risk assessment indicate that malathion, diflubenzuron, and methyl parathion are unlikely to present an unacceptable risk to the species in rivers that could receive insecticide drift or runoff. Also, the Alabama red-bellied turtle is unlikely to be affected by food-source depletion because the species' diet consists primarily of plant material. To eliminate the risk of accidental direct spray, aircraft will avoid overflights of the Mobile River system in Baldwin and Mobile Counties, Alabama, where the red-bellied turtle is known to occur.

Conclusion. May affect.

Sternotherus depressus—Flattened musk turtle

Status. The flattened musk turtle was listed as threatened on June 11, 1987 (52 FR 22430, June 11, 1987).

Description. This turtle is aquatic and has a flattened, dark-brown-to-orange carapace (maximum length of 4.7 inches (12 cm)) and a pinkish-yellow plastron. The head is greenish with a dark reticulum that may be spotted along the top of the snout (Mount, 1981; as cited in FWS, 1990). The male turtle attains a body length of 2.4 to 2.6 inches (6 to 6.6 cm), and the female is slightly larger (2.8 to 3.0 inches (7 to 7.6 cm)) (Close, 1982; as cited in FWS, 1990). Other distinguishing characteristics include two barbels on the chin, webbed feet, and the male's long, spine-tipped tail (Ernst and Barbour, 1972; as cited in FWS, 1990).

Habits. This species has a low reproductive rate; one or two clutches per season with an average of three eggs per clutch are delivered each year. The turtle reaches sexual maturity after 4 to 8 years (Close, 1982; as cited in FWS, 1990). Mollusks are its primary food source (Marion et al., 1986; as cited in FWS, 1990).

Habitat. Free-flowing creeks and small rivers are the flattened musk turtle's optimum habitats, and they usually contain vegetated shallows interspersed with deeper pools where numerous crevices, submerged rocks, and boulders provide refuge. Other factors include an abundant supply of mollusks, low-silt load and deposits, low-nutrient content and bacterial count, and moderate temperature (FWS, 1990). The species is currently restricted to Alabama's Black Warrior River upstream from the Bankhead Dam (52 FR 22430, June 11, 1987). The Fish and Wildlife Service's "Counties of Occurrence" list includes Blount, Cullman, Etowah, Marshall, Lawrence, Tuscaloosa, Winston, Jefferson, and Walker Counties, Alabama. However, Jefferson and Walker are not cotton-producing counties.

Factors in Species Decline. The historical range of the flattened musk turtle extended throughout the upper Black Warrior River drainage. The species was isolated upstream by the fall line or the steep edge of the Alabama coastal plain. This natural barrier prevented hybridization with other turtle species, preserving the flattened musk turtle as a genetically unique species. However, water impoundments eliminated the barrier and facilitated the overlap of habitat and possibly the hybridization of the flattened musk turtle with a similar species, *Sternotherus minor peltifer* (Iverson, 1977; as cited in FWS, 1990). The Bankhead Dam, constructed before the wide-scale development of the river system, remains the only effective barrier to hybridization, and populations of the flattened musk turtles above the dam are the only ones known to be genetically pure. The decline of the species above and below the dam also has been facilitated by habitat loss through development, siltation, and pollution. Historically, silt-laden runoff from mining operations, agriculture, industrial or residential development, and forest-harvesting operations affected the molluscan fauna on which the turtles feed and buried portions of the rocky habitat. Water quality continues to be a concern. Development in the Black Warrior River basin has polluted numerous streams, and some of these streams are now classified for agricultural and industrial use only. Diseases and parasites have been found in past studies of

flattened musk turtle populations. A disease characterized by a gram-negative septicemia was found in 1988; nearly one-fourth of all turtles captured at one site were diseased, and one-half of all turtles observed basking were believed to be sick (Dodd et al., 1988; as cited in FWS, 1990). Finally, flattened musk turtle collecting by dealers has seriously damaged some populations (FWS, 1990).

Recovery Plan. The objective of the Flattened Musk Turtle Recovery Plan is to remove the flattened musk turtle from the list of threatened species. Actions to be taken include improving habitat, assessing the nature and magnitude of all threats to this species, reducing the isolation of individual populations, and decreasing the incidence of disease (FWS, 1990).

Analysis of Program Impacts. The results of the aquatic species risk assessment indicate that malathion, diflubenzuron, and methyl parathion are unlikely to present an unacceptable risk to the species in rivers that could receive insecticide drift or runoff. Also, the flattened musk turtle is unlikely to be affected by food-source depletion because the species' diet consists primarily of mollusks, which should not be adversely affected by control program activities (see the species-specific discussions for clams). To eliminate the risk of an accidental direct spray, aircraft will avoid overflights of sections of the Black Warrior River in Alabama where the flattened musk turtle is known to occur.

Conclusion. May affect.

***Drymarchon corais couperi*—Eastern indigo snake**

Status. The eastern indigo snake was listed as threatened on March 3, 1978 (43 FR 4028, January 31, 1978).

Description. This snake attains a length of approximately 8 feet (2.63 m) and has a lustrous black body. Except for red or cream markings on the chin, throat, and sometimes the cheeks, this lustrous black appearance is uninterrupted for the entire span of the snake's body. Other identifying characteristics are the large, smooth scales and the undivided anal plate (FWS, 1982b).

Habits. A generalized predator, the eastern indigo snake will feed on any vertebrate small enough to overpower, including fish, frogs, toads, snakes, lizards, turtles, turtle eggs, small alligators, birds, and small mammals. The snake is not territorial and may cover a wide range, depending on the season. During the winter (December through April), the species inhabits a range of about 19.5 acres (4.8 hectares) and then increases its living area through the warm spring months to a summer (August through November) range of 91.4 hectares (FWS, 1982b).

Habitat. Although the eastern indigo snake is not a true migrating species, it exhibits a seasonal shift in habitats (Speake et al., 1978; as cited in FWS, 1982b). Dry, sandy ridges are the preferred winter habitat, and the snake often takes refuge in the abandoned nesting burrows of the gopher tortoise (*Gopherus polyphemus*) found in the sandhill environment. The summer habitat includes adjacent, wetter areas. The species may occur in Mobile, Baldwin, Washington, Escambia, and Covington Counties, Alabama. In addition, the Fish and Wildlife Service's "Counties of

Occurrence" list includes Bullock and Conecuh Counties, Alabama.

Factors in Species Decline. Loss of habitat through increased urbanization and agricultural development has contributed to the population decline of the eastern indigo snake. Habitat fragmentation has isolated snake populations and increased highway mortality. The decline of the gopher tortoise, also a threatened species, has reduced the area of the snake's potential habitat by decreasing the number of sandy ridge burrows available for winter refuge (FWS, 1982b).

Recovery Plan. The recovery objective is to remove the eastern indigo snake from the federal endangered and threatened species list. Delisting will occur when numerous populations of the snake are stable or expanding and when habitat areas are adequately protected in the historical range of the species. Also included in the plan are the development of population-monitoring methods, the study of captive breeding and restocking potentials, the study of habitat requirements for juveniles, the reestablishment of the species where feasible, and the improvement of public attitudes and behavior toward the snake (FWS, 1982b).

Analysis of Program Impacts. Although the terrestrial wildlife risk assessment indicates that direct exposure to malathion and methyl parathion presents an unacceptable risk to the eastern indigo snake, the species' size, vertebrate diet, and wide foraging range should eliminate any potential risk from the boll weevil control program. Insecticide exposure through secondary poisoning should not affect the species because of its large size and the high doses that would be required to affect it. Although adverse effects to the indigo snake are unlikely, the risks would be minimized by emphasizing the use of diflubenzuron in cotton fields near the snake's habitat. However, the sole use of diflubenzuron all season is not a feasible option because of the need to follow early diflubenzuron treatments with one of the organophosphate insecticides— malathion or methyl parathion. Aerial applications of the organophosphate insecticides should be avoided within 300 feet (91 m) of known indigo snake habitat. Within this buffer, only ground application equipment will be used.

Conclusion. May affect.

Notropis cahabae—Cahaba shiner

Status. The Cahaba shiner was listed as an endangered species on October 12, 1990 (55 FR 42966, October 25, 1990).

Description. *N. cahabae* is a small, delicate-bodied and silvery colored shiner that attains a length of about 2.5 inches (6.4 cm). The body also possesses a peach-colored, narrow stripe over the dark lateral stripe (55 FR 10083, March 19, 1990). The Cahaba shiner differs from a closely related species, the mimic shiner (*N. volucellus*), in several ways—the Cahaba shiner's lateral stripe does not expand before the causal spot, the species lacks a predorsal dark blotch, its dorsal caudal peduncle scales are uniformly dark and pigmented, and its predorsal scales are broadly outlined and diffuse (Mayden and Kuhadjda, 1989; as cited in 55 FR 10083, March 19, 1990).

Habits. The Cahaba shiner spawns from late May through June and apparently has a more limited spawning period than other fish of similar adult size. Prespawning populations of the species have been observed at the tail of a long pool, in a moderate current with a depth of 1.2 to 2.0 feet (36.5 to 61 cm) and just before the head of a main riffle (Ramsey, 1982; as cited in 55 FR 10083, March 19, 1990).

Habitat. The species prefers large shoal areas of the main channel of the Cahaba River, usually in quieter waters less than 1.64 feet (50.3 cm) deep and just below swift riffle areas (Howell et al., 1982; as cited in 55 FR 10083, March 19, 1990). Also, the shiner prefers patches of sandy substrate at the edge of or scattered throughout gravel beds or downstream of larger rocks and boulders. Furthermore, the species occurs in streams with a stable riparian zone and water temperatures ranging from 23 to 62°F (11 to 29°C). Similar to the mimic shiner, the species probably requires a river with sufficient populations of small crustaceans, insect larvae, and algae for food (Gilbert and Burgess, 1980; as cited in 55 FR 10083, March 19, 1990). The Cahaba shiner currently exists in a 60-mile (97-km) section of the Cahaba River, which extends from a point 3 miles (4.8 km) northeast of Heiberger to about 4 miles (6.4 km) above Booth Ford (Pierson et al., 1989a; Howell et al., 1982; as cited in 55 FR 10083, March 19, 1990). The habitat range passes through Perry, Bibb, and Shelby Counties, Alabama (55 FR 10083, March 19, 1990).

Factors in Species Decline. The degradation of water quality in the Cahaba River has been the primary factor in the decline of the Cahaba shiner. For example, residential and industrial sewage effluents, urban runoff, and siltation from construction activities, agriculture, forestry, and coal strip-mining all have contributed to the reduction in water quality. Furthermore, the Cahaba shiner's low numbers and scattered populations, its restricted range, and its limited spawning interval make the species susceptible to any natural or humanmade environmental disturbances (55 FR 10083, March 19, 1990).

Recovery Plan. None.

Analysis of Program Impacts. The results of the aquatic species risk assessment indicate that malathion presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from shiner habitat. If the Cahaba shiner's diet includes aquatic invertebrates, the species may be indirectly affected by food supply depletion. The possible risk from malathion could be reduced to acceptable levels if malathion is used no closer than 115 feet (35 m) upgradient of known shiner habitat. Best management practices should be strongly encouraged to decrease the runoff from adjacent fields. The use of diflubenzuron or methyl parathion is unlikely to affect the species during program operations. To protect the species from accidental spray, aircraft overflights of the shiner's known habitat will be avoided in the Cahaba River in Perry, Bibb, and Shelby Counties, Alabama.

Conclusion. May affect.

Speoplatyrhinus poulsoni—Alabama cavefish

Status. The Alabama cavefish was originally listed as threatened on October 11, 1977 (42 FR 45528, September 9, 1977). The species was reclassified as endangered on October 28, 1988 (53 FR 37970, September 28, 1988).

Description. The Alabama cavefish is an extremely rare, monotypic species with a standard length range of 1.2 to 2.3 inches (31.2 to 58.3 mm) (Cooper, 1980; as cited in FWS, 1985d). Adapted to life in the dark, cool environment of a cave, the Alabama cavefish has no externally visible eyes or any obvious pigmentation. However, it does appear pinkish white (Cooper and Kuehne, 1974; as cited in FWS, 1985c).

Habits. Few data have been accumulated on the Alabama cavefish, and fewer than 100 individuals are thought to exist. However, the species probably possesses the characteristics generally noted for troglodytic amblyopsids—namely, low reproductive rates with great longevity, long generation time, small numbers of offspring, few reproductive females, and branchial incubation and fry protection. The diet is undetermined, but copepods, isopods, amphipods, and small crayfish are likely food sources (FWS, 1985c).

Habitat. The Alabama cavefish's only known habitat is Key Cave in Lauderdale County, Alabama. This area has been designated as critical habitat (42 FR 45528, September 9, 1988).

Factors in Species Decline. Groundwater degradation is a possible threat to the Alabama cavefish population in Key Cave. A hydrologic study conducted for a proposed landfill indicated that the recharge areas for Key Cave lie within a heavily used agricultural area (Aley, 1986; as cited in 53 FR 37970, September 28, 1988). The Florence Demonstration Project, a sewage sludge disposal program, is operated on likely recharge areas. Thus, contaminants from agricultural row crops and the sewage program may ultimately enter the Key Cave aquifer and could reduce the cavefish's viability. In addition, any reduction in the size of the gray bat (*Myotis grisescens*) maternity colony in Key Cave will affect the Alabama cavefish. Guano from the bats provides the cave ecosystem with the supply of organic matter necessary to maintain the cave's food chain (53 FR 37970, September 28, 1988).

Recovery Plan. The recovery objective is to remove the species from the federal list of endangered and threatened species. (Note that the recovery plan has not been updated to reflect the Fish and Wildlife Service's recent reclassification of the Alabama cavefish as an endangered species.) The delisting objective will be considered fulfilled when five distinct and healthy, unthreatened populations exist outside of the Key Cave area. The plan also includes the study of hydrological patterns in the Key Cave area, assessment and monitoring of the aquifer supplying Key Cave, assessment and protection of the cave's energy flow (particularly the gray bat's effect on cave energy dynamics), and a complete biological study of the Key Cave ecosystem (FWS, 1985c).

Analysis of Program Impacts. The GLEAMS model was unable to predict the potential insecticide concentrations in the cavefish's habitat because the species lives in a protected

cave that is fed by an undetermined level of groundwater flow. However, the results of the aquatic species risk assessment for other endangered, threatened, and proposed species suggest that malathion may present a risk to the species. The cavefish is unlikely to experience direct toxic effects because the species' only known habitat, Key Cave, should adequately protect it from insecticide exposure. Although all insecticides have the potential to affect aquatic invertebrate populations, which may be the cavefish's food source, the natural protection afforded by the cave also should reduce that risk. Also, groundwater contamination is unlikely because none of the control program insecticides has demonstrated significant leaching potential. Standard operating procedures for the boll weevil program reduce the risk that groundwater may become contaminated. These procedures incorporate adequate safeguards for mixing, loading, and storing insecticides. The procedures also guide program personnel in the proper handling of emergency spills and the disposal of insecticide containers. To protect the Alabama cavefish from the possible risk from the use of malathion, APHIS will avoid the use of malathion around the recharge areas sustaining Key Cave in Lauderdale County, Alabama. In these areas only diflubenzuron or methyl parathion will be used. Also overflights of Key Cave and its known recharge areas will be avoided.

Conclusion. May affect.

Etheostoma (=_Nothonotus_) _wapiti_—Boulder darter

Status. The boulder darter was listed as endangered on October 3, 1988 (53 FR 33998, September 1, 1988).

Description. Like many of the darters, the boulder darter is a very rare, small fish. Its maximum length is about 3 inches (7.6 cm) (Dr. David Etnier, University of Tennessee, personal communication to Richard G. Biggins; as cited in FWS, 1989). Both the male and female boulder darter have olive-gray bodies, although the females are slightly lighter. Both sexes have a gray-black bar below the eye and a similarly colored spot behind the eye (FWS, 1989).

Habits. The boulder darter prefers warm water riverine environments with a moderate to swift current, a large boulder or slab rock substrate, and a water depth of 2 feet (0.6 cm) (O'Bara and Etnier, 1987; as cited in FWS, 1989). Juvenile boulder darters probably occur in habitat areas with smaller substrate size (Charles Saylor, Tennessee Valley Authority, personal communication to Richard G. Biggins; as cited in FWS, 1989). Although little is known about the boulder darter's food habits, the available information on the food habits of other *Nothonotus* spp. indicates that the species may feed primarily on immature aquatic insects (Stile, 1972; as cited in FWS, 1989).

Habitat. A 60-mile segment of the Elk River in Giles and Lincoln Counties, Tennessee, and Limestone County, Alabama, and a 2-mile (3.2-km) section of the Richland and Indian Creeks in Giles County are the only known remaining habitats for the boulder darter (FWS, 1989).

Factors in Species Decline. The traditional habitat boundaries of the boulder darter in the Elk and Tennessee Rivers have been substantially reduced by the construction

of river impoundments. Cold water releases from the Tims Ford Reservoir prevent boulder darter repopulation on the upper Elk River. Flooding by other dams and pollution from a manufacturing facility also have contributed to the population's decline. Because of the limited area of the boulder darter's habitat, any reduction in water quality or habitat size could impose additional threats to its survivability (FWS, 1989).

Recovery Plan. The primary goal of the recovery plan is to restore viable populations to significant portions of the historic range. To accomplish this goal, the plan advocates the preservation of current populations and habitat areas, the search for additional populations and habitat areas suitable for reintroduction efforts, and the implementation of a monitoring program to assess population levels and habitat conditions. The species will be considered for reclassification from endangered to threatened status when two distinct, viable populations exist, when studies of the biological and ecological requirements have been completed, and when the data from such studies are incorporated into a successful management strategy. The species will be considered for delisting from Federal protection when three distinct, viable populations exist, when all studies of the biological and ecological requirements have been completed, and when there are no foreseeable threats to the survival of any of the populations (FWS, 1989).

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, malathion presents an unacceptable risk to the boulder darter in rivers that could receive drift and runoff from treated areas immediately upgradient from darter habitat. If the boulder darter's diet includes aquatic invertebrates, the species may be indirectly affected by food supply depletion. To prevent possible risks from malathion, its use should be limited to 60 feet (18 m) upstream from the boulder darters' habitat. Drift buffers of 200 feet (61 m) for aerial applications and 50 feet (15 m) for ground applications should be instituted for fields abutting rivers containing boulder darter habitat. Best crop management practices should be strongly encouraged to decrease runoff from adjacent fields. The use of diflubenzuron or methyl parathion is unlikely to directly affect the species during program operations. To protect the species from accidental direct spray, aircraft overflights of known current habitat in the Elk River in Limestone County, Alabama, will be avoided.

Conclusion. May affect.

***Etheostoma boschungi*—Slackwater darter**

Status. The slackwater darter was listed as threatened on October 11, 1977 (42 FR 45528, September 9, 1977).

Description. Little growth and development data exist for the slackwater darter, but medium-sized individuals are generally 1.6 to 2.8 inches (40 to 70 mm) long (Williams and Robison, 1980; as cited in FWS, 1984c). The species is best recognized by its three prominent dorsal saddles and a bold, blue-black subocular bar (FWS, 1984c).

Habits. Various species of crustaceans and insects constitute the slackwater darter's food supply (FWS, 1984c).

Habitat. The slackwater darter occupies two distinct habitats, depending on its breeding cycle. The nonbreeding habitat includes small to moderately large streams with slow-moving water. In this habitat, the slackwater darters aggregate over silty gravel, silt, or mud substrates containing a detritus layer of twigs and decayed leaves. During the breeding season, the fish inhabit seepage pools in adjacent fields and woods that are created after spring floods. However, the fish must have access to the open stream waters from the breeding habitat. Critical habitat for the slackwater darter has been established in Lauderdale County, Alabama. The habitat in Lauderdale County includes all permanent or intermittent streams (December to June) that are tributaries to Cypress Creek or its tributaries upstream from the junction of Burcham Creek, including Burcham Creek but excluding Threet Creek (42 FR 45528, September 9, 1977). Outside of the critical habitat area, populations of the slackwater darter are found in the Flint River in Madison County, Alabama, and in Swan Creek in Limestone County, Alabama (FWS, 1984c). In addition, the Fish and Wildlife Service's "Counties of Occurrence" list includes Morgan County, Alabama.

Factors in Species Decline. Spreading urbanization and the degradation of surface and groundwater sources have destroyed much of the slackwater darter's habitat. The historic and current habitat is surrounded by agricultural and cattle lands. Consequently, chemical and biological wastes from adjacent farms, cattle operations, sewage lines, and septic tanks have contributed to the decline in water quality (FWS, 1984c).

Recovery Plan. The removal of the slackwater darter from the federal endangered and threatened species list is the primary goal of the Slackwater Darter Recovery Plan. This goal is to be achieved by protecting one or more critical habitat areas in at least three tributaries of the Tennessee River system, protecting species' spawning areas by land purchase or cooperative agreement, and having monitoring programs indicate that there are stable or expanding populations and that the habitat is stable or improving (FWS, 1984c).

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, malathion presents an unacceptable risk to the slackwater darter in rivers that could receive runoff from the cotton fields sprayed over the entire watershed. Also, malathion presents an unacceptable risk to the slackwater darter in rivers that could receive drift and runoff from treated areas immediately upgradient from darter habitat. Any of the three insecticides may cause a temporary reduction in the species' food supply. The possible risk from malathion could be reduced to acceptable levels if no more than 550 acres (3% of the total cotton acres in the watershed) of cotton are treated at any one time. Consequently, the use of malathion should be limited over the watershed and limited to 120 feet (37 m) upstream from the slackwater darter's habitat. Drift buffers of 200 feet (61 m) for aerial applications and 50 feet (15 m) for ground applications should be instituted for fields abutting rivers containing slackwater darter habitat. Best crop management practices should be strongly encouraged to decrease runoff from adjacent fields. The use of diflubenzuron or methyl parathion is unlikely to affect the species during program operations. To protect the species from accidental direct spray, aircraft overflights

of critical habitat in Lauderdale and Morgan Counties, Alabama, will be avoided.

Conclusion. May affect.

***Percina tanasi*—Snail darter**

Status. The snail darter was originally listed as endangered on October 9, 1975 (40 FR 47506, October 9, 1975). The species was reclassified as threatened on August 6, 1984 (49 FR 27514, July 5, 1984).

Description. The snail darter reaches a maximum length of 3 to 4 inches (7.6 to 10.2 cm) and a mean adult weight of 0.18 ounces (5 g). The upper portion of the fish's side has a brownish background color with traces of green, while the lower portion is lighter with dark blotches. Dark brown saddle marks are present across the back, and the belly is white. The head has various shades of brown with traces of yellow (49 FR 27514, July 5, 1984; FWS, 1982c).

Habits. Small snails are the snail darter's most common food source (Ono et al., 1983). During the spawning season, eggs are deposited on gravel or rocks, and hatching occurs in about 15 to 20 days. Larvae then drift to the main stem of the Tennessee River and spend their first 5 to 7 months there. Juveniles migrate back to the shoal areas of tributaries to spend the rest of their lives, reaching a maximum age of 5 to 6 years (FWS, 1982c).

Habitat. Gravelly shoals are the snail darter's preferred habitat. The species is now found in six tributaries of the Tennessee River and in short sections of the Tennessee River's main stem. This habitat lies in Jackson and Madison Counties, Alabama (49 FR 27514, July 5, 1984). The Fish and Wildlife Service's "Counties of Occurrence" list includes Marshall County, Alabama.

Factors in Species Decline. The historic range of the snail darter is unknown because the species was never surveyed before the wide-scale construction of river impoundments in the Tennessee River drainage. As demonstrated by the Tellico Dam project in the 1970's, however, water impoundments destroy snail darter habitat by flooding gravelly shoal areas. Also, pesticide runoff and stream siltation from adjacent agricultural lands may threaten the species (49 FR 27514, July 5, 1984).

Recovery Plan. The ultimate goal of the Snail Darter Recovery Plan is to complete the delisting of the species from the federal endangered and threatened species list. The species will be considered recovered when all present and foreseeable threats to its continued survival are eliminated and when one of the following alternatives are met: (1) suitable habitat areas of the Tennessee River are inhabited by independently reproducing populations; (2) additional Tennessee River tributary populations are discovered and existing populations remain viable, and (3) stable or expanding populations exist in five separate streams of the historic range, either through the maintenance of current populations or the expansion of these populations (FWS, 1982c).

Analysis of Program Impacts. Malathion presents an unacceptable risk to the snail darter in rivers that could receive drift and runoff from treated areas immediately

upgradient from darter habitat. Any of the three program insecticides may cause a temporary reduction in the species' food supply. The possible risk from malathion could be reduced to acceptable levels if the use of malathion is limited to 120 feet (37 m) upstream from the snail darter's habitat. Drift buffers of 200 feet (61 m) for aerial applications and 50 feet (15 m) for ground applications should be instituted for fields abutting rivers containing snail darter habitat. Best crop management practices should be strongly encouraged to decrease runoff from adjacent fields. The use of diflubenzuron or methyl parathion is unlikely to directly affect the species during program operations. To protect the species from accidental direct spray, aircraft overflights of critical habitat will be avoided.

Conclusion. May affect.

Acipenser oxyrhynchus desotoi—Gulf sturgeon

Status. The gulf sturgeon was proposed for listing as a threatened species on May 2, 1990 (55 FR 18357, May 2, 1990).

Description. The gulf sturgeon is a large, nearly cylindrical subspecies of the Atlantic sturgeon (*Acipenser oxyrhynchus*). It possesses an extended snout, ventral mouth, and chin barbels and the upper lobe the tail is longer than the lower lobe. Adult sturgeons range from 1.8 to 2.4 meters (6 to 8 feet) or more in length, and the females are generally larger than the males. The species' scaleless skin is brown dorsally and pale ventrally and is imbedded with five rows of bony plates (55 FR 18357, May 2, 1990).

Habits. *A. oxyrhynchus desotoi* is a bottom-feeding species that eats primarily invertebrates, including brachiopods, insect larvae, mollusks, worms, and crustaceans. Most adult feeding occurs in the Gulf of Mexico and its estuaries. As an anadromous species, however, reproduction occurs in fresh water and individuals probably breed in the same river system in which they hatched. Spawning occurs in areas of deep water with clean rock, gravel, or sand bottoms (Barkuloo, 1988; as cited in 55 FR 18357, May 2, 1990). The gulf sturgeon is a slow-maturing, long-lived fish; females require 8 to 12 years to reach sexual maturity, while males need 7 to 10 years (Huff, 1975; as cited in 55 FR 18357, May 2, 1990).

Habitat. The gulf sturgeon's historical range extended from the Mississippi River to Tampa Bay, Florida. Although the species still occurs sporadically throughout its historic range, it is now essentially restricted to the eastern half of the Gulf of Mexico where the predominantly hard bottoms provide suitable feeding habitat (Barkuloo, 1988; as cited in 55 FR 18357, May 2, 1990). The Suwannee River contains the healthiest remaining population of gulf sturgeon, but within the past 5 years the species has also been identified in Lake Pontchartrain, Louisiana; the Mobile River system in Alabama; and the Pascagoula and Pearl Rivers in Mississippi. The Fish and Wildlife Service's "Counties of Occurrence" list includes all large rivers in Alabama and Florida leading to the Gulf of Mexico.

Factors in Species Decline. The primary factor in the decline of the gulf sturgeon has been the impoundment of the

major rivers and their tributaries in the gulf region. Because the sturgeon is apparently unable to pass through dam systems, the species can no longer access spawning areas upstream from river impoundments. The dredging, desnagging, and spoil deposition activities associated with channel improvement and maintenance also may degrade the species' preferred spawning habitat. Poor water quality may be an additional threat to the gulf sturgeon because heavy pesticide use has occurred in the watersheds for all of the major rivers in the species' historic range, and some have been contaminated with heavy metals and industrial contaminants (55 FR 18357, May 2, 1990).

Recovery Plan. None.

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, malathion presents a risk to the gulf sturgeon in rivers that could receive drift and runoff from cotton fields immediately upgradient from sturgeon habitat. Drift buffers of 200 feet (61 m) for aerial applications and 50 feet (15 m) for ground applications should be instituted for fields abutting gulf sturgeon habitat. Because the gulf sturgeon is an opportunistic feeder with a varied diet, a short-term reduction in aquatic invertebrate populations should not affect the species. Best crop management practices should be strongly encouraged to decrease the runoff from adjacent fields. The use of diflubenzuron or methyl parathion is unlikely to affect the species during program operations. To protect the species from accidental spray, aircraft overflights of the sturgeon's known habitat will be avoided.

Conclusion. May affect.

***Tulotoma magnifica*—Tulotoma snail**

Status. The tulotoma snail was listed as an endangered species on February 8, 1991 (56 FR 797, January 9, 1991).

Description. *T. magnifica* is a monotypic, live-bearing snail of the family Viviparidae. It is gill-breathing and operculate and possesses a globular shell that is typically ornamented with spiral lines of knob-like structures (56 FR 797, January 9, 1991). Also, the species is distinguished by an oblique aperture with a concave margin (Burch, 1982; as cited in 56 FR 797, January 9, 1991).

Habits. The tulotoma snail prefers cool, well-oxygenated, clean, and free-flowing waters, and occurs in both the mainstem river and the lower portions of large tributaries (Hershler, 1989; as cited in 56 FR 797, January 9, 1991). Like other members of the Viviparidae, the tulotoma snail is a filter-feeder (56 FR 797, January 9, 1991).

Habitat. *T. magnifica* occurs in riffles and shoals and is strongly associated with boulder/cobble substrates. It has been found at depths over 15 feet (5 m) in strong currents and tightly clings to the undersides of large rocks during daylight hours. Although the species was once abundant in the main channels of the Coosa and Alabama Rivers, it is currently restricted to four localized populations in the lower, unimpounded portions of Coosa River tributaries in Alabama: Kelly Creek in St. Clair and Shelby Counties; Weogufka and Hatchet Creeks in Coosa County; and Ohatchee Creek in Calhoun County. Also, a single population exists

in the Coosa River between the Jordan Dam and Wetumpka in Elmore County (56 FR 797, January 9, 1991).

Factors in Species Decline. The decline of the tulotoma snail is attributed primarily to the loss of suitable habitat caused by extensive channel modifications in the Coosa-Alabama River system. Water impoundment projects for hydropower and dredging for navigation have destroyed much of the species' historic range in the mainstems of the Coosa and Alabama Rivers and backwater from the impoundments has affected the lower reaches of tributaries. These projects have also decreased water quality; hydropower discharge has altered the dissolved oxygen content in river water and has elevated water temperature regimes. In addition, siltation and industrial and municipal waste problems in the Coosa drainage have been implicated in the species' decline (56 FR 797, January 9, 1991).

Recovery Plan. None.

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, malathion presents a risk to the tulotoma snail in rivers that could receive drift and runoff concentrations from treated areas immediately upgradient from snail habitat. Drift buffers of 200 feet (61 m) for aerial applications and 50 feet (15 m) for ground applications of malathion should be instituted for fields abutting streams and rivers containing tulotoma snail habitat. Best crop management practices should be strongly encouraged to decrease runoff from adjacent fields. The use of diflubenzuron and methyl parathion is unlikely to affect the species during program operations. To protect the species from accidental direct spray, aircraft overflights of the species' known habitat will be avoided.

Conclusion. May affect.

Potamilus inflatus—Inflated heelsplitter mussel

Status. The inflated heelsplitter mussel was proposed for listing as a threatened species on October 27, 1989 (54 FR 43835, October 27, 1989).

Description. *P. inflatus* has an oval, compressed to moderately inflated thin shell that is brown to black. Juveniles' shells may have green rays. Adults attain a maximum shell length of 5.5 inches (140 mm) (Stern, 1976; as cited in 54 FR 43835, October 27, 1989). The valves may gape anteriorly, and there is a prominent posterior wing that may extend anterior to the beaks in juveniles. The umbos are low and the umbonal cavity is very shallow. The nacre is pink to purple. The species is distinguished from *P. ohioensis* (pink papershell), a closely related species, by shell morphology; compared to *P. ohioensis*, the shell and teeth of *P. inflatus* are more delicate, the shell is darker and has a pointed posterior, and *P. inflatus* appears more inflated with a more developed and rounded posterior ridge. Also, the posterior wing of *P. inflatus* is more pronounced and is abruptly rounded over the dorsum (Hartfield, 1988; as cited in 54 FR 43835, October 27, 1989).

Habits. This mussel prefers habitat areas in slow-to-moderate currents with soft, stable substrates (Stern, 1976; as cited in 54 FR 43835, October 27, 1989). The species has been found in sand, mud, silt, and sandy-gravel but not in large gravel or armored gravel (Hartfield, 1988; as cited in

54 FR 43835, October 27, 1989). Usually, the species occurs on the protected side of bars and may be found at depths greater than 20 feet (6 meters). Although the species has been collected from silty areas, viable populations may not be possible in a silt substrate; adult mussels can probably survive limited amounts of silt where juveniles would suffocate (Hartfield, 1988; as cited in 54 FR 43835, October 27, 1989). Also, the mussels found in silty areas may have been established before the deposition of the silt.

Habitat. The inflated heelsplitter once occurred in the Amite and Tangipahoa Rivers, Louisiana; the Pearl River, Mississippi; and the Tombigbee, Black Warrior, Alabama, and Coosa Rivers in Alabama (Hurd, 1974; Stern, 1976; Hartfield, 1988; all as cited in 54 FR 43835, October 27, 1989). Currently, the species is limited to stretches of the Amite River in Louisiana and the Tombigbee and Black Warrior Rivers in Alabama (Stern, 1976; Hartfield, 1988; both as cited in 54 FR 43835, October 27, 1989). The remaining habitat areas occur in the cotton-producing counties of Greene, Hale, Washington, and Clarke, Alabama.

Factors in Species Decline. Habitat modification is the main cause of the decline of the inflated heelsplitter mussel. The species' preferred habitat areas have been reduced by river channelization, impoundments, flood control levees, channel erosion, gravel mining, and dredging operations. Also, industrial and urban pollution have contributed to the decline. Because the known remaining populations are small and isolated, limited genetic variation may reduce the species' ability to adapt to environmental disturbances (54 FR 43835, October 27, 1989).

Recovery Plan. None.

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control program insecticides presents a risk to the inflated heelsplitter mussel in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over inflated heelsplitter mussel habitat would present an unacceptable risk to this species. Aircraft overflights of inflated heelsplitter mussel habitat in cotton-producing counties of Greene, Hale, Washington, and Clarke, Alabama, will be avoided.

Conclusion. May affect.

Pleurobema taitianum—Judge Tait's mussel

Status. Judge Tait's mussel was listed as an endangered species on May 7, 1987 (52 FR 11169, April 7, 1987).

Description. Judge Tait's mussel is a bivalve mollusk about 2 inches (50 mm) long, 1.8 inches (45 mm) high, and 1.2 inches (30 mm) wide. The shell is brown to brownish black, obliquely triangular, and inflated. It has narrowly pointed beaks that are directed forward, a very shallow but distinct furrow, pink-tinted nacre, and shallow beak cavities (52 FR 11169, April 7, 1987).

Habits. The species has historically been found in moderate-to-large rivers with a moderate-to-swift current.

The preferred habitats are riffle-run or shoal areas with stable substrates ranging from sandy gravel to gravel-cobble (52 FR 11169, April 7, 1987).

Habitat. Only four sites with suitable habitat remain: the bendway of the Tombigbee River, Sumter County, Alabama; the East Fork of the Tombigbee River, Monroe and Itawamba Counties, Mississippi; the Buttahatchie River, Monroe County, Mississippi; and the Sipsey River, Pickens and Greene Counties, Alabama. The Fish and Wildlife Service's "Counties of Occurrence" list includes Greene, Lamar, and Sumter Counties, Alabama.

Factors in Species Decline. This clam population has declined because of habitat alteration. Modifying the Tombigbee River into a series of impoundments to form a barge canal has adversely affected these species by dredging, increasing silt, reducing water flow, and, possibly, disturbing the movements of host fish.

Recovery Plan. None.

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control program insecticides presents a risk to Judge Tait's mussel in rivers that could receive runoff from an entire watershed area. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over Judge Tait's mussel habitat would present an unacceptable risk to this species. Aircraft overflights of Judge Tait's mussel habitat in the Tombigbee and Sipsey Rivers of Alabama will be avoided.

Conclusion. May affect.

***Pleurobema marshalli*—Marshall's mussel**

Status. Marshall's mussel was listed as endangered on May 7, 1987 (52 FR 11169, April 7, 1987).

Description. Marshall's mussel is a bivalve mollusk about 2.4 inches (60 mm) long, 2 inches (50 mm) high, and 1.2 inches (30 mm) wide. The shell has a shallow umbonal cavity, a rounded subovate or slightly elliptical outline, nearly terminal beaks, and very low pustules or welts on the postventral surface (52 FR 11169, April 7, 1987).

Habits. The species has historically been found in moderate-to-large rivers with a moderate-to-swift current. The preferred habitats are riffle-run or shoal areas with stable substrates ranging from sandy gravel to gravel-cobble (52 FR 11169, April 7, 1987). The fish hosts of these clams have not been identified.

Habitat. The only remaining viable habitat is a gravel bar in a bendway of the Tombigbee River in Sumter County, Alabama.

Factors in Species Decline. This clam population has declined because of habitat alteration. Modifying the Tombigbee River into a series of impoundments to form a barge canal has adversely affected this species by dredging, increasing silt, reducing water flow, and, possibly,

disturbing the movements of host fish. (52 FR 11169, April 7, 1987).

Recovery Plan. None.

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control program insecticides presents a risk to the Marshall's mussel in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over Marshall's mussel habitat would present an unacceptable risk to this species. Aircraft overflights of Marshall's mussel habitat in the Tombigbee River in Sumter County, Alabama, will be avoided.

Conclusion. May affect.

***Epioblasma (=Dysnomia) penita*—Penitent mussel**
(The FWS recognizes the following name combinations as equivalent to *Epioblasma penita* (Conrad): *Unio penitus* (Conrad), *Margarito (Unio) penitus* (Conrad), *Margaron (Unio) penita* (Conrad), *Truncilla penita* (Conrad), *Dysnomia penita* (Conrad), *Epioblasma penita* (Conrad), and *Plagiola (Plagiola) penita* (Conrad).)

Status. The penitent mussel was listed as endangered on May 7, 1987 (52 FR 11169, April 7, 1987).

Description. The penitent mussel is a bivalve mollusk about 2.2 inches (55 mm) long, 1.6 inches (40 mm) high, and 1.3 inches (34 mm) wide. The shell is yellowish, greenish yellow, or tawny, sometimes with darker dots. The shell is rhomboid with irregular growth lines and a radially straw-colored nacre (52 FR 11169, April 7, 1987). Females have a large, radially grooved swelling projecting behind the shell.

Habits. The preferred habitats are riffle-run or shoal areas with stable substrates ranging from sandy gravel to gravel-cobble (52 FR 11169, April 7, 1987). Specific host fish of this species are unknown.

Habitat. The only remaining viable habitats are in the Buttahatchie River, Lamar County, Alabama; the East Fork of the Tombigbee River; and one place in the bendway of the Tombigbee River in Sumter County, Alabama.

Factors in Species Decline. This clam population has declined because of habitat alteration. Modifying the free-flowing Tombigbee River into a series of impoundments to form a barge canal has adversely affected this species by dredging, increasing silt, reducing water flow, and, possibly, disturbing the movements of host fish.

Recovery Plan. None.

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control program insecticides presents a risk to the penitent mussel in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately

upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over penitent mussel habitat would present an unacceptable risk to this species. Aircraft overflights of penitent mussel habitat in the Buttahatchie River in Lamar County, Alabama, and the East Fork of the Tombigbee River in Sumter County, Alabama, will be avoided.

Conclusion. May affect.

***Lampsilis virescens*—Alabama lamp pearly mussel**

Status. The Alabama lamp pearly mussel was listed as endangered on July 14, 1976 (41 FR 24064, June 14, 1976).

Description. The Alabama lamp pearly mussel is a medium-size, thin freshwater mussel, 1.5 inches (37 mm) long. The shell is elliptical, smooth, and shiny, greenish to straw-colored, and faintly rayed.

Habits. The Alabama lamp pearly mussel inhabits sand and gravel substrates in small to medium streams. Life cycle specifics and periods of reproduction are unknown. Host fish species are unknown.

Habitat. The Alabama lamp pearly mussel is restricted to the Paint Rock River and its tributaries, Hurricane Creek, Estill Fork, and Larkin Fork in Jackson County, Alabama.

Factors in Species Decline. The reasons for the decline of this species are not clearly understood, but impoundments, siltation, dredging and channelling, and pollution may be primary causes.

Recovery Plan. The objective of the Alabama Lamp Pearly Mussel Recovery Plan is to maintain and restore viable populations of this species in a significant portion of its historic range and to remove the species from the federal list of endangered and threatened species. The species shall be considered recovered when the following two criteria are met:

1. A viable population is established on the Paint River and two additional river systems.

2. The species and its habitat are protected from present and foreseeable human-related or natural threats (FWS, 1985d).

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control program insecticides presents a risk to the Alabama lamp pearly mussel in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over Alabama lamp pearly mussel habitat would present an unacceptable risk to this species. Aircraft overflights of Alabama lamp pearly mussel habitat in the Paint Rock River and its tributaries, Hurricane Creek, Estill Fork, and Larkin Fork in Jackson County, Alabama, will be avoided.

Conclusion. May affect.

Fusconaia cuneolus—Fine-rayed pigtoe

Status. The fine-rayed pigtoe was listed as endangered on July 14, 1976 (41 FR 24064, June 14, 1976).

Description. The fine-rayed pigtoe is medium-sized (approximately 3 inches (75 mm) in length) and distinguished by a yellow-green to brown shell with fine green rays and satin-like appearance. The anterior end of the valve is rounded, and the ventral margin is nearly straight.

Habits. The fine-rayed pigtoe is most often encountered in riffle and run areas of free-flowing streams of moderate gradient and firm, cobble, or gravel substrates. The species is intolerant of lentic conditions and rarely occurs in backwater or pool habitats. The species is tachytictic (that is, the glochidia, or larvae, are released shortly after fertilization in the spring and summer). Specific fish hosts are unknown (FWS, 1984d).

Habitat. This species has been found in tributaries of the Tennessee River above Mussel Shoals, Alabama, and the Paint Rock River in Jackson County, Alabama. The Fish and Wildlife Service's "Counties of Occurrence" list includes Jackson County, Alabama.

Factors in Species Decline. The intense industrial and agricultural development of the Tennessee Valley has destroyed this species' habitat by impoundment, siltation, channelization, and pollution.

Recovery Plan. The objective of the Fine-rayed Pigtoe Recovery Plan is to restore this species to a significant portion of its historic range and to remove it from the federal list of threatened and endangered species. This species shall be considered recovered when the following criteria are met:

1. A population with recent evidence of recruitment exists in the present range of the species.

2. A viable population exists in one additional stream within the historic range of the species.

3. The species and its habitat are protected from present and foreseeable human and natural threats.

4. Coal-related problems in the Powell and Clinch Rivers are noticeably reduced (FWS, 1984d).

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control program insecticides presents a risk to the fine-rayed pigtoe in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over fine-rayed pigtoe habitat would present an unacceptable risk to this species. Aircraft overflights of fine-rayed pigtoe habitat in the tributaries of the Tennessee River, including the Paint Rock River in Jackson County, Alabama, will be avoided.

Conclusion. May affect.

Plethobasus cooperianus—Orange-footed pearly mussel (=pimple back)

Status. The orange-footed pearly mussel was listed as endangered on June 14, 1976 (41 FR 24064, June 14, 1976).

Description. The orange-footed pearly mussel is a large freshwater mussel, 3.7 inches (95 mm) long, 1.8 inches (46 mm) wide, and 3.1 inches (78 mm) high. This species has a large heavy shell, which is nearly circular in outline. The posterior surface is covered with tubercles, varying in size, shape, and arrangement. It is yellowish brown to rusty or chestnut brown; nacre color varies from white to pink.

Habits. Cumberlandian freshwater mussels are most often observed in clean, fast-flowing water in silt-free rubble, gravel, or sand substrates. The orange-footed pearly mussel is tachytictic (that is, glochidia, or larvae, are released by the female shortly after fertilization in the spring or summer). Specific hosts are unknown, but possible host fish include the sauger (*Stizostedion canadense*), the host of the related species *P. cyphyus*.

Habitat. Historically, the orange-footed pearly mussel was common in the Ohio River between St. Marys and Marietta, the Wabash River, and the Cumberland River. This species is presently known only from the Tennessee below Pickwick (Hardin County, Tennessee), Guntersville (Marshall County, Alabama), and Fort Loudon Dams (Loudon County, Tennessee); the Cumberland below Cordell Hull Dam (Smith County, Tennessee); and the lower Ohio below Kentucky and Barklay Dams. The Fish and Wildlife Service's "Counties of Occurrence" list includes Marshall County, Alabama.

Factors in Species Decline. The reasons for the decline of this species are not entirely understood, although impoundments, siltation, and pollution may be principal causes.

Recovery Plan. The objective of the Orange-footed Pearly Mussel Recovery Plan is to maintain and restore populations of the species to a significant portion of its historical range. Actions toward this end include preserving habitat on the Tennessee, Cumberland, and Ohio Rivers and conducting studies to determine the essential habitat, life history, and population biology of the species. The species will be considered recovered under the following conditions:

1. A viable population exists in the Tennessee, Cumberland, and Ohio Rivers.
2. Viable populations exist in two other rivers, through discovery or establishment.
3. The species and its habitat are protected.
4. Siltation problems are noticeably reduced (FWS, 1984e).

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control program insecticides presents a risk to the orange-footed pearly mussel in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could

receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over orange-footed pearly mussel habitat would present an unacceptable risk to this species. Aircraft overflights of orange-footed pearly mussel habitat in Marshall County, Alabama, will be avoided.

Conclusion. May affect.

***Toxolasma (=Carunculina) cylindrellus*—Pale lilliput pearly mussel**
(The FWS recognizes the following name combination as being equivalent to *Toxolasma cylindrellus*: *Carunculina cylindrella*.)

Status. The pale lilliput pearly mussel was listed as endangered on June 14, 1976 (41 FR 24064, June 14, 1976).

Description. The pale lilliput pearly mussel is a bivalve mollusk 1.7 inches (44 mm) long, 1 inch (25 mm) high, and 0.6 inches (16 mm) wide. The shell is cloth-like with yellowish-green coloration and no rays. The valves are solid, elongate, and subinflated with a full beak and no beak sculpturing (FWS, 1984f).

Habits. The species has historically been found in small rivers and streams in shallow, fast-flowing water with clean and stable substrates (FWS, 1984f). This species is bradytictic (that is, glochidia, or larvae, are retained over the winter in the female's gills and released the following spring). The fish hosts are unknown, although experimental studies have successfully transformed juveniles from infected sunfish.

Habitat. The pale lilliput pearly mussel is now known only in the Paint Rock River and its headwater tributary streams, including Hurricane Creek and Estill Fork in northern Alabama and southern Tennessee. The Fish and Wildlife Service's "Counties of Occurrence" list includes Jackson County, Alabama.

Factors in Species Decline. There is little information to indicate whether the population of these clams has declined because of habitat alteration. However, the Cumberlandian faunal group as a whole has suffered from impoundment, siltation, and pollution of the Tennessee and Cumberland Rivers. The completion of the Normandy Dam on the Duck River in 1976 and the Wood's (1952) and Tim's Ford Dams (1970) on the Elk River may have contributed to the decline in population.

Recovery Plan. The objective of the Pale Lilliput Pearly Mussel Recovery Plan is to restore this species to a significant portion of its historical range and to remove the species from the federal list of threatened and endangered species. This species shall be considered recovered when the following criteria are met:

1. A viable population exists in the Paint Rock River, Estill Fork, and Hurricane Creek.

2. Viable populations exist in two additional rivers.

3. The species and its habitat are protected from present and foreseeable human-related and natural threats.

4. Substrate quality in the Paint Rock River watershed is noticeably improved with regard to siltation (FWS, 1984f).

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control program insecticides presents a risk to the pale lilliput pearly mussel in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over pale lilliput pearly mussel habitat would present an unacceptable risk to this species. Aircraft overflights of pale lilliput pearly mussel habitat in the Paint Rock River and its tributaries, Hurricane Creek and Estill Fork, in northern Alabama, will be avoided.

Conclusion. May affect.

Lampsilis orbiculata—Pink mucket pearly mussel

Status. The pink mucket pearly mussel was listed as endangered on June 14, 1976 (41 FR 24064, June 14, 1976).

Description. The pink mucket pearly mussel is a bivalve mollusk 4.1 inches (105 mm) long, 3.2 inches (82 mm) high, and 2.4 inches (61 mm) wide. The outer shell covering can be glossy in younger individuals and dull in older ones. Their colors are yellowish or greenish brown, with wide, greenish rays present in young individuals. Valves are inflated, thick, heavy, unsculptured, and gaped at the anterior-ventral base (FWS, 1985e).

Habits. The species is found in medium to large rivers in habitats ranging from silt to boulders, rubble, gravel, and sand substrates. The species is most often associated with larger rivers and moderate- to fast-flowing water. The pink mucket pearly mussel is bradytictic (that is, glochidia, or larvae, are retained over the winter in the female's gills and released the following spring). Specific host fish species are unknown.

Habitat. The greatest concentration of this species is reported in the Tennessee River (Marshall, Colbert, and Lauderdale Counties in Alabama, and Hardin, Loudon, Rhea, and Meigs Counties in Tennessee) and the Cumberland River (Smith County, Tennessee) in Tennessee; the Osage River (Osage County, Missouri); the Meremec River (Jefferson County, Missouri) in Missouri; and the Spring (Fulton County, Arkansas), Black (Butler County, Missouri), and Little Black (Ripley County, Missouri, and Clay County, Arkansas) Rivers in Arkansas and Missouri. Other specimens have been reported in the Paint Rock River in Alabama. Sanctuaries have been established in portions of the Tennessee, Cumberland, and Clinch Rivers. The Fish and Wildlife Service's "Counties of Occurrence" list includes Colbert, Jackson, Marshall, and Morgan Counties in Alabama.

Factors in Species Decline. The pink mucket pearly mussel appears to have adapted to the impounded Tennessee and Cumberland Rivers. Unlike other Cumberland fauna, the river-lake conditions in the upper reaches of these impoundments may be suitable for survival and propagation of this species. As with other Cumberland fauna, impoundments,

siltation, and pollution of the river habitats may have contributed to the decline of the species.

Recovery Plan. The objective of the Pink Mucket Pearly Mussel Recovery Plan is to restore this species to a significant portion of its historical range and to remove it from the federal list of endangered and threatened species. This species shall be considered recovered when the following criteria are met:

1. Two additional populations are established in rivers other than the Tennessee, Cumberland, and Meremec.

2. Additional mussel sanctuaries are established in river systems known to contain the species.

3. An education program is established for the public.

4. The species and habitat are protected from present and foreseeable human-related and natural threats (FWS, 1985e).

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control program insecticides presents a risk to the pink mucket pearly mussel in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over pink mucket pearly mussel habitat would present an unacceptable risk to this species. Aircraft overflights of pink mucket pearly mussel habitat in the Tennessee River and the Paint Rock River in Alabama will be avoided.

Conclusion. May affect.

Pleurobema plenum—Rough pigtoe

Status. The rough pigtoe was listed as endangered on July 14, 1976 (41 FR 24064, June 14, 1976).

Description. The rough pigtoe is a medium-size, 2.6-inch (65-mm) long freshwater mussel. Its valves are heavy and solid. Its yellow- to red-brown surface is cloth-like and marked with irregular, concentric growth rings. Nacre color varies from white to pink, red, or orange (FWS, 1984g).

Habits. Cumberlandian freshwater mussels are most often observed in clean, fast-flowing water in silt-free rubble, gravel, or sand substrates. The rough pigtoe is found in sand or gravel substrates of medium to large rivers. The rough pigtoe is tachytictic (that is, glochidia, or larvae, are released by the female shortly after fertilization in mid- to late summer). Specific fish hosts are unknown.

Habitat. This species was formerly found in the Ohio, Cumberland, and Tennessee Rivers and southwest to Arkansas and Kansas. Now the rough pigtoe is found in the Tennessee River downstream from the Guntersville Dam in Marshall County, Alabama, the Wilson Dam in Colbert and Lauderdale Counties, Alabama, and the Pickwick Dam in Hardin County, Tennessee; the Cumberland River downstream of the Cordell

Hull Dam in Smith County, Tennessee; the Clinch River between Kyles Ford and Sneedville in Hancock County, Tennessee; the Green River at Lock and Dam #5; and the Barren River at Lock and Dam #1 in Kentucky.

Factors in Species Decline. The reasons for the decline of this species are not entirely understood; impoundments, siltation, and pollution may be principal causes.

Recovery Plan. The objective of the Rough Pigtoe Recovery Plan is to maintain and restore populations of this species to a significant portion of its historical range. Actions toward this end include preserving current populations and habitats, soliciting public support in protecting this species, and determining the feasibility of returning this species to its historic range. The rough pigtoe can be considered recovered under the following conditions:

1. A viable population exists in the Tennessee, Clinch, Cumberland, and Green Rivers.

2. Viable populations exist in two additional rivers.

3. The species is protected from present and foreseeable threats.

4. There have been noticeable reductions in siltation problems and improvements in substrate quality (FWS, 1984g).

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control program insecticides presents a risk to the rough pigtoe in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over rough pigtoe habitat would present an unacceptable risk to this species. Aircraft overflights of rough pigtoe habitat in the Tennessee River in Alabama will be avoided.

Conclusion. May affect.

***Fusconaia edgariana*—Shiny pigtoe**

Status. The shiny pigtoe was listed as endangered on July 14, 1976 (41 FR 24064, June 14, 1976).

Description. The shiny pigtoe is in the family Unionidae. No other description is available.

Habits. Cumberlandian freshwater mussels are most often observed in clean, fast-flowing water in silt-free rubble, gravel, or sand substrates. The shiny pigtoe, like other *Fusconaia* species, is a riffle species, intolerant of lentic conditions. Specific fish hosts are unknown.

Habitat. This species has recently been found in the North Fork Holston River in Smyth County, Virginia; the Clinch and Powell Rivers in Lee and Scott Counties, Virginia, and Clairborn and Hancock Counties, Tennessee; and the Paint Rock River in Jackson County, Alabama.

Factors in Species Decline. The reasons for this species' decline are not fully understood; impoundments, siltation, and pollution may be major causes.

Recovery Plan. None.

Analysis of Program Impacts. According to results of the aquatic species risk assessment, none of the control program insecticides presents a risk to the shiny pigtoe in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over shiny pigtoe habitat would present an unacceptable risk to this species. Aircraft overflights of shiny pigtoe habitat in the Paint Rock River in Jackson County, Alabama, will be avoided.

Conclusion. May affect.

***Quadrula stapes*—Stirrup shell**
(The USFS recognizes the following name combinations as equivalent to *Quadrula stapes* (Lea): *Unio stapes* (Lea), *Margarita (Unio) stapes* (Lea), *Margaron (Unio) stapes* (Lea), *Orthonymus stapes* (Lea).)

Status. The stirrup shell was listed as endangered on May 7, 1987 (52 FR 11169, April 7, 1987).

Description. The stirrup shell is a bivalve mollusk about 2.2 inches (55 mm) long and 1.2 inches (30 mm) wide. The shell is yellowish green; the green zigzag markings of young individuals become brown with age. It is irregularly quadrate, with a sharp posterior ridge, truncated posterior, tubercles, and a silvery-white nacre that is thinner and iridescent behind (52 FR 11169, April 7, 1987).

Habits. This species has historically been found in moderate to large rivers with moderate-to-swift current. The preferred habitats are riffle-run or shoal areas with stable substrates ranging from sandy gravel to gravel-cobble (52 FR 11169, April 7, 1987). Specific host fish of this species are unknown.

Habitat. The present known distribution of this clam is limited to a reach of the Tombigbee River from near Epes, Alabama, upstream to just above the confluence of Tibbee Creek in Sumter County, Alabama. A specimen has also been collected in the lower Sipsey River, Pickens and Greene Counties, Alabama (52 FR 11169, April 7, 1987). The Fish and Wildlife Service's "Counties of Occurrence" list includes Greene and Sumter Counties, Alabama.

Factors in Species Decline. The population of these clams has declined because of habitat alteration. The modification of the free-flowing habitat of the Tombigbee River into a series of impoundments to form a barge canal has adversely affected this species through dredging, increased siltation, water flow reduction, and possible disturbance of host fish movements.

Recovery Plan. None.

Analysis of Program Impacts. According to the results of the aquatic species risk assessment, none of the control

program insecticides presents a risk to the stirrup shell in rivers that could receive runoff from an entire watershed. Also, none of the insecticides presents an unacceptable risk to the species in rivers that could receive drift and runoff from treated areas immediately upgradient from mussel habitat. Although unlikely, an emergency jettison of pesticide over stirrup shell habitat would present an unacceptable risk to this species. Aircraft overflights of stirrup shell habitat in the Tombigbee River in Sumter County, Alabama, and the Sipsey River in Greene County, Alabama, will be avoided.

Conclusion. May affect.

***Palaemonias alabamae*—Alabama cave shrimp**

Status. The Alabama cave shrimp was listed as endangered on October 7, 1988 (53 FR 34698, September 7, 1988).

Description. This species is colorless and transparent, like other albinistic cave shrimp. It is 0.8 inches (20 mm) long. The other species in this genera, the Kentucky cave shrimp (*Palaemonias ganteri*), is also endangered.

Habits. This species is a troglobite (lives only in caves). Its diet and reproductive behavior are unknown.

Habitat. This species is known only in Shelta and Bobcat Caves, Madison County, Alabama, and may have been extirpated from Shelta Cave. Other species found in this habitat are southern cavefish (*Typhlichthys subterraneous*), cave salamander (*Gyrinophilus palleucus*), and the cave crayfish (*Avticambarus jonesi*). Shelta Cave is owned by the National Speleological Society and is gated to prevent unauthorized visitors; Bobcat Cave is owned by Redstone Arsenal, under the control of the U.S. Army. The Fish and Wildlife Service's "Counties of Occurrence" list includes Madison County, Alabama.

Factors in Species Decline. The biggest threat to the Alabama cave shrimp may be groundwater contamination, possibly by DDT. The shrimp's survival is also affected by its apparently low reproductive capabilities, confined habitat, and inability to elude captors (53 FR 34698, September 7, 1988).

Recovery Plan. None.

Analysis of Program Impacts. The GLEAMS model was unable to predict the potential insecticide concentrations for the three control program chemicals in the Alabama cave shrimp's habitat because it lives in a protected cave that is fed by an undetermined level of groundwater flow. However, the results of the aquatic species risk assessment for other endangered and threatened species suggest that malathion may present a risk to the species. The Alabama cave shrimp is unlikely to experience direct toxic effects because the species' cave habitat should adequately protect it from insecticide exposure. Although all insecticides have the potential to affect aquatic invertebrate populations, which may be the Alabama cave shrimp's food source, the natural protection afforded by caves should reduce that risk. Also, groundwater contamination is unlikely because none of the control program insecticides has demonstrated significant leaching potential. To eliminate any possible risks from groundwater contamination, standard operating procedures for

the boll weevil program incorporate adequate safeguards for mixing, loading, and storing insecticides. The procedures also guide program personnel in the proper handling of emergency spills and disposal of insecticide containers. The use of these procedures will ensure that there is no effect on the Alabama cave shrimp or its habitat. Diflubenzuron and methyl parathion are unlikely to affect the species during program activities. To eliminate the risk of an accidental direct spray, aircraft overflights of Shelta and Bobcat Caves and their recharge areas in Madison County, Alabama, will be avoided.

Conclusion. May affect.

Clematis socialis—Alabama leather flower

Status. The Alabama leather flower was listed as endangered on October 27, 1986 (51 FR 34422, September 26, 1986).

Description. This species is a member of the Ranunculaceae family. The plants are 8 to 12 inches (0.2 to 0.3 m) high, and the upper leaves are three to five foliate. Flowers are solitary, blue violet, and urn or bell shaped. Fruits are aggregates of achenes (51 FR 34422, September 26, 1986).

Habits. The Alabama leather flower has a rhizomatous habit and forms dense clones. The flowers bloom from April to May. Very little is known about the pollination of the Alabama leather flower.

Habitat. This species is found in two sites in northwestern Alabama: St. Clair and Cherokee Counties. It is found in silty-clay soil with grass-sedge vegetation along highway rights-of-way. No critical habitat has been designated. St. Clair and Cherokee Counties are the only two counties included in the Fish and Wildlife Service's "Counties of Occurrence" list.

Factors in Species Decline. The decline in population of the Alabama leather flower has been primarily because of mechanical disturbances, such as maintenance of highway rights-of-way and residential development. Because of its horticultural potential, the species may have been affected by overcollection.

Recovery Plan. None.

Analysis of Program Impacts. The Alabama leather flower may be adversely affected by a short-term reduction in insect pollinators. To protect the species from a depletion of essential insect pollinators, the control program insecticides should not be applied within 300 feet (91.4 m) of known Alabama leather flower habitat during pollination time.

Conclusion. May affect.

Ptilimnium nodosum—Harperella (Piedmont Bishop's weed)

Status. Harperella was listed as endangered on October 28, 1988 (53 FR 37982, October 28, 1988).

Description. Harperella is an annual member of the parsley family (*Apiaceae*). The plants are 0.7 to 3.25 feet (0.2 to 1 m) tall. The leaves are hollow, quill-like structures, and the small white flowers occur in heads.

Habits. Harperella flowers from May until frost. The riverine form of the species is tolerant of periodic, moderate flooding. This adaptation allows Harperella to survive under changing water levels that few plants can tolerate. Very little is known about pollinators.

Habitat. The species typically occurs in two habitat types: rocky or gravelly shoals and on the margins of swift-flowing streams, and the edges of intermittent pineland ponds or wet savanna meadows. Stream populations are found in DeKalb County, Alabama. The Fish and Wildlife Service's "Counties of Occurrence" list also includes Cherokee County, Alabama.

Factors in Species Decline. Because of very specific habitat requirements, the species is highly affected by minor perturbations. Changes in water flow, increases in siltation, and changes in nutrient concentration in streams have all been linked to the species decline.

Recovery Plan. None.

Analysis of Program Impacts. Because harperella is highly susceptible to increased siltation in riverine habitats, the species may be adversely affected by cultural control methods that increase erosion. The species also may be affected by a short-term reduction in insect pollinators. To protect the species from a depletion of essential insect pollinators, the control program insecticides should not be applied within 300 feet (91.4 m) of known harperella habitat during pollination time.

Conclusion. May affect.

***Marshallia mohrii*—Mohr's Barbara's buttons**

Status. Mohr's Barbara's buttons were declared threatened on October 7, 1988 (53 FR 34701, September 7, 1988).

Description. Mohr's Barbara's buttons is a member of the sunflower family and an erect perennial herb 1 to 2.3 feet (30 to 70 cm) tall. The leaves are alternate, lanceolate-ovate in shape, firm-textured, and 1.2 to 8 inches (3 to 20 cm) long.

Habits. The flowers of Mohr's Barbara's buttons occur in multi-headed inflorescences and are pale pink to lavender in color. Flowering occurs from mid-May through June. Very little is known about the pollinators of Mohr's Barbara's buttons.

Habitat. This species is found in moist, prairie-like openings in woodlands and along shale-bedded streams. It prefers sandy clay soils that are alkaline, high in organic matter, and seasonally wet. Associated species include grasses (*Andropogon*, *Panicum*), sedges (*Rhynchospora*, *Carex*), *Siliphium confertifolium*, *Ruellia pinetorum*, *Allium cerenuum*, *Physostegia*, *and Asclepias englemanniana*. The forest type is mixed hardwoods, primarily Shumard oak, willow oak, and pine. Mohr's Barbara's buttons has been found only in Floyd County, Georgia, and in Bibb, Etowah, and Cherokee Counties in Alabama.

Factors in Species Decline. The decline of Mohr's Barbara's buttons is believed to be the result of habitat destruction caused by highway improvements and conversion to agricultural lands. The plant is also threatened by

collection and vandalism because of its high visibility when in bloom.

Recovery Plan. None.

Analysis of Program Impacts. Mohr's Barbara's buttons may be adversely affected by a short-term reduction in insect pollinators. To protect the species from a depletion of essential insect pollinators, the control program insecticides should not be applied within 300 feet (91.4 m) of known Mohr's Barbara's buttons habitat during pollination time.

Conclusion. May affect.

***Sagittaria secundifolia*—Kral's water-plantain**

Status. Kral's water-plantain was listed as a threatened species on May 14, 1990 (55 FR 13911, April 13, 1990).

Description. Kral's water-plantain is a submersed or emersed aquatic perennial that is distinguished by a stout, elongated rhizome approximately 4 inches (10 cm) in length, hairy filaments, linear leaves, and spreading or reflexed sepals. The species displays two types of leaves depending on the velocity and depth of the water it inhabits. In swift shallows, the leaves are linear, rigid, and sickle-shaped, 2 to 3 inches (5 to 8 cm) long, and 0.007 to 0.02 inches (2 to 5 mm) wide. In quiet, deep waters the leaves are more quill-like, longer (4 to 12 inches (10 to 30 cm)), linear in shape, and tapered. Separate male and female flowers are produced on a stalk 4 to 19.5 inches (10 to 50 cm) long. The petals are inconspicuous in the female flowers; however, in the male flowers they are white and 0.4 to 0.6 inches (1 to 1.5 cm) long. The fruit consists of a cluster of achenes approximately 0.01 inches (2 mm) in length (Kral, 1982, 1983; as cited in 55 FR 13911, April 13, 1990).

Habits. Although infrequent, Kral's water-plantain may flower from May through July and intermittently into autumn (Kral, 1982, 1983; as cited in 55 FR 13911, April 13, 1990). However, flowering has been observed in only 1% of the plants known to exist. These flowering plants were in direct sunlight in water shallow enough for emergent leaves. The species is clonal, and reproduction is primarily asexual, which suggests that the species may possess low genetic variability (55 FR 13911, April 13, 1990).

Habitat. Kral's water-plantain typically occurs on narrow stream bottoms bounded by steep slopes, in frequently exposed shoals, or rooted among loose boulders in quiet pools up to 3.3 feet (1 m) in depth. Plants are locally distributed where suitable habitat exists and grow in pure stands or in association with other submergent plants. It is currently known to occur in three areas in the upper free-flowing reaches of the Little River drainage system in northeast Alabama. These habitat areas are located in Cherokee and DeKalb Counties, Alabama (Whetstone, 1988; Whetstone et al., 1988; both as cited in 55 FR 13911, April 13, 1990).

Factors in Species Decline. The critical factor in the decline of Kral's water-plantain has been the elimination or adverse modification of the species' preferred habitat. For example, the clearing of adjacent river banks for

silviculture, residential-recreational growth, surface mining, and agricultural development all have destroyed habitat. Furthermore, these activities have contributed to water-quality degradation, an increase in stream turbidity, and siltation (Kral, 1982, 1983; as cited in 55 FR 13911, April 13, 1990). Additionally, eutrophication and water impoundments have affected the viability of this plant (55 FR 13911, April 13, 1990).

Recovery Plan. None.

Analysis of Program Impacts. Because Kral's water-plantain is clonal and reproduces primarily by asexual reproduction, the use of insecticides in the control program should not affect the species. However, because the species is susceptible to increased siltation in its riverine habitat, the species may be affected by cultural control methods that increase erosion, such as certain stalk destruction methods.

Conclusion. May affect.

Trillium reliquum—Relict trillium

Status. The relict trillium was listed as endangered on May 4, 1988 (53 FR 10884, April 4, 1988).

Description. *Trillium reliquum* is an herbaceous perennial of the lily family. It has sessile flowers on S-curved stems. Flowers are greenish to brownish purple or occasionally pure yellow. Fruit is an oval berry-like capsule.

Habits. Flowers appear in early spring, and the plant dies back to the rhizome after the fruit matures. Very little is known about the pollination of the relict trillium.

Habitat. The relict trillium prefers moist hardwood forests in soils with high organic content. The species also occurs on less than optimum sites, such as power and sewer line rights-of-way. There have been populations in Henry and Lee Counties, Alabama.

Factors in Species Decline. These populations have declined because of loss or alteration of habitat resulting from residential development and conversion of habitat to pine monoculture, pasture, and row crop agriculture.

Recovery Plan. None.

Analysis of Program Impacts. The relict trillium may be adversely affected by a short-term reduction in insect pollinators. To protect the species from a depletion of essential insect pollinators, the control program insecticides should not be applied within 300 feet of known relict trillium habitat during pollination time.

Conclusion. May affect.

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